BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY)

ZOOLOGY

VOL. I

1950–1953

PRINTED BY ORDER OF THE TRUSTEES OF

THE BRITISH MUSEUM (NATURAL HISTORY)

LONDON : 1954

DATES OF PUBLICATION OF THE PARTS

No. 1.	17 January 1950
No. 2.	20 March 1950
No. 3.	31 March 1950
No. 4.	29 August 1950
No. 5.	3 November 1951
No. 6.	26 October 1951
No. 7.	6 June 1952
No. 8.	5 August 1952
No. 9.	31 July 1952
No. 10.	11 December 1952
No. 11.	13 January 1953
No. 12.	27 November 1953

PRINTED IN
GREAT BRITAIN
AT THE
BARTHOLOMEW PRESS
DORKING
BY
ADLARD AND SON, LTD.

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ERRATUM

Plates 7–9.

For NOTOCANTHUS read NOTACANTHUS.

ON SOME SPECIES OF LERNAEA

(CRUSTACEA, COPEPODA: PARASITES OF FRESH-WATER FISH)

J. P. HARDING

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ZOOLOGY Vol. 1 No. 1
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Xuf.

Pp. 1–27; 95 Text-figures

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is to be issued in five series, corresponding to the Departments of the Museum.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 1, of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued January 1950 *Price Seven shillings and sixpence*

ON SOME SPECIES OF *LERNAEA* (CRUSTACEA, COPEPODA: PARASITES OF FRESHWATER FISH)

By J. P. HARDING

(*With ninety-five text-figures*)

SYNOPSIS

Twenty-eight species of *Lernaea* are recognized, of which fourteen are represented in the collections of the British Museum. Nine of these are new species. In addition there are seven names in the literature which are relegated to the synonymy. A key to the twenty-eight recognized species is given and the fourteen species in the Museum are described and figured.

One result of the renewed interest in the freshwater fisheries of Africa and other countries in recent years has been an accumulation of the parasites of these fish in the British Museum with requests for their identification. Attempts to name the species of *Lernaea* on the basis of existing descriptions and keys soon showed that a high proportion of them were new, and that Cunnington's (1914) and Wilson's (1917 & 1918) revisions and keys are out of date.

There is no need here to repeat recriminations against Wilson (1917) for transposing the names for the genera *Lernaea* and *Lernaeocera*. The inevitable confusion caused by this strict interpretation of the Rules of Nomenclature has fortunately been lessened by the fact that subsequent workers have, however unwillingly, nearly all agreed to follow.

As is often the case with degenerate parasitic forms, the characters used to distinguish between species are often ill-defined and not easily seen. Wilson often expressed the opinion that species of *Lernaea* and other parasitic copepods could readily be distinguished by reference to their appendages; but I have found extraordinarily little difference between the appendages of one species and those of another. The first four pairs of pereiopods, which will be referred to as legs 1 to 4 in this paper, are the only appendages that are easily examined as they are flat, and as each has a number of setae and spines I expected variations in their arrangements to provide useful characters for distinguishing species. Unfortunately I could find hardly any variations. The precise arrangement of the setae and spines was investigated in fourteen species, and in thirteen of them it was identical, only one of them could be separated on this basis. Table 1 gives the arrangement of the setae and spines in the thirteen species. *L. bistricornis* is included although I was able to see only legs 3 and 4; all four pairs of legs were seen in the other species. *L. haplocephala* differs from all these species in having four setae instead of five on the terminal segment of each exopod (Table 2, p. 19). *L. oryzophila*, according to Monod's (1932) description and figures, differs from the other species, having four instead of three spines on the last segment of the second exopod and two spines instead of three on the last segment of the fourth exopod. *L. dolabroides* (Wilson, 1918, figs. 77 and 78) seems to have a quite different setation of its legs.

TABLE I

Arrangement of the setae and spines on the legs of *L. bagri*, *L. barbicola*, *L. barilii*, *L. barnimiana*, *L. bistricornis*, *L. cyprinacea*, *L. diceracephala*, *L. longa*, *L. lophiara*, *L. palatae*, *L. piscinae*, *L. tilapiae*, and *L. tuberosa*

		Leg 1	*Leg 2*	*Leg 3*	*Leg 4*
Exopod	spines	1.1.2	1.1.3	1.1.3	1.1.3
	setae	1.1.5	1.1.5	1.1.5	1.1.5
Endopod	spines	0.0.2	0.0.2	0.0.2	0.0.2
	setae	1.1.4	1.2.4	1.2.4	1.2.3

The other appendages are even less useful than the legs for separating one species of *Lernaea* from another. Wilson (1920, p. 7) claims that *L. haplocephala* may be distinguished by the 'small spherical terminal joint of the maxillipedes, with its four curved claws'. This may have been true of the specimen he examined, but I find that the maxillipedes of the type specimens of *L. haplocephala* have five claws like any other species and that the terminal segment does not appear to have any specific shape. Fig. 34 gives the arrangement of the mouth parts as far as I have been able to see these very minute appendages.

We are left with the shape of the body and with the internal anatomy for distinguishing species. Unfortunately it is difficult to study one without destroying, or at least distorting, the other, and I have neglected a study of the internal anatomy in favour of the shape of the body and its processes, and in particular that of the anchor. I am restricting the use of the word 'head' to that small, rounded part which bears the antennae and the mouth parts. The swollen part with processes which are usually described as 'cephalic processes', 'cephalic arms', or 'cephalic horns' I propose to call the anchor and its arms, as this describes both the appearance and the function of this part of the body. The anchor is often difficult to remove from the flesh of the fish without damage, and I have adopted the method of cutting out the part of the fish with the parasite embedded in it and placing it in a tube with a solution of potassium hydroxide to which a little chlorazol black has been added. If this is left for about twenty-four hours the tissues of the fish are usually softened sufficiently for the *Lernaea* easily to be removed; the chlorazol black stains the chitin of the parasite a dark blue. The external shape of the animal is well preserved by this method and the appendages can be examined without difficulty. The egg-sacs should be removed before placing the parasite in the hydroxide or they will be destroyed.

All drawings and measurements of specimens recorded in this paper have been made with the aid of a camera lucida. The total length of a specimen is understood to mean the length from the front of the head to the end of the abdomen, allowance being made for bends and curves in the body. Parts of the anchor which may project in front of the head and the furcal setae are not included in this measurement. The measurement and drawing of curved specimens was helped by the use of gimbals which enabled the specimen to be held in any position on the stage of the microscope. The gimbals, similar in principle to those of a ship's compass, but with sufficient

friction in the bearings to prevent free swinging, were made of concentric cylinders of perspex, as shown in Fig. 1. The whole is submerged in formalin in a glass vessel and the specimen is placed in the central cylinder, which is closed at the bottom to form a dish.

I have found the shape of the anchor and its arms to provide the most useful characters for taxonomic purposes. In spite of the fact that the shape of the anchor is liable to be distorted by meeting bones and other hard obstructions during its growth in the body of the fish, each species has a characteristic form which varies within limits which are usually definable provided sufficient material is available.

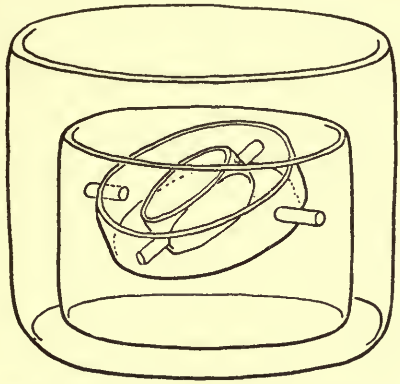


FIG. 1. Gimbals for tilting the specimen into positions required for drawing or measuring.

The abdomen and the pregenital prominences of each species examined have been drawn with some care from more than one aspect as I have found them useful in separating species. The shape of these parts is not so easily influenced by the site of attachment of the parasite, but on the other hand there is often a difference in the shape of these parts of a young individual and those of an old one. The characters of the immature specimens are often less well defined than those of adult specimens, and the adult female seems to continue to grow and develop specific form for some time after eggs are first produced.

The positions of the legs on the body have been recorded wherever possible with an estimate of the range of variability.

The amount of torsion and its direction is very variable; but worth recording because some species show little torsion and in others considerable torsion is the rule. In some species, such as *L. barnimiana*, the torsion is not only variable in direction and extent in different specimens but often changes its direction along the length of the one individual.

Cunnington (1914) remarks on the rarity of copepod parasites on the fish he collected from Lake Tanganyika. Lake Nyasa, however, seems to be very rich in species. More information is required about the seasonal distribution of the different species. Miss R. H. Low tells me that she found *Lernaea* on many of the specimens of *Bagrus* that she collected in August and that by November the *Bagrus* were free of parasites but the *Tilapia* were infected. She had the impression that the parasites

had transferred their attentions from *Bagrus* to *Tilapia*; but an examination of the specimens shows that there are two distinct species of *Lernaea* involved, *L. bagri* and *L. tilapiae*, described below.

Lernaea cyprinacea Linnaeus

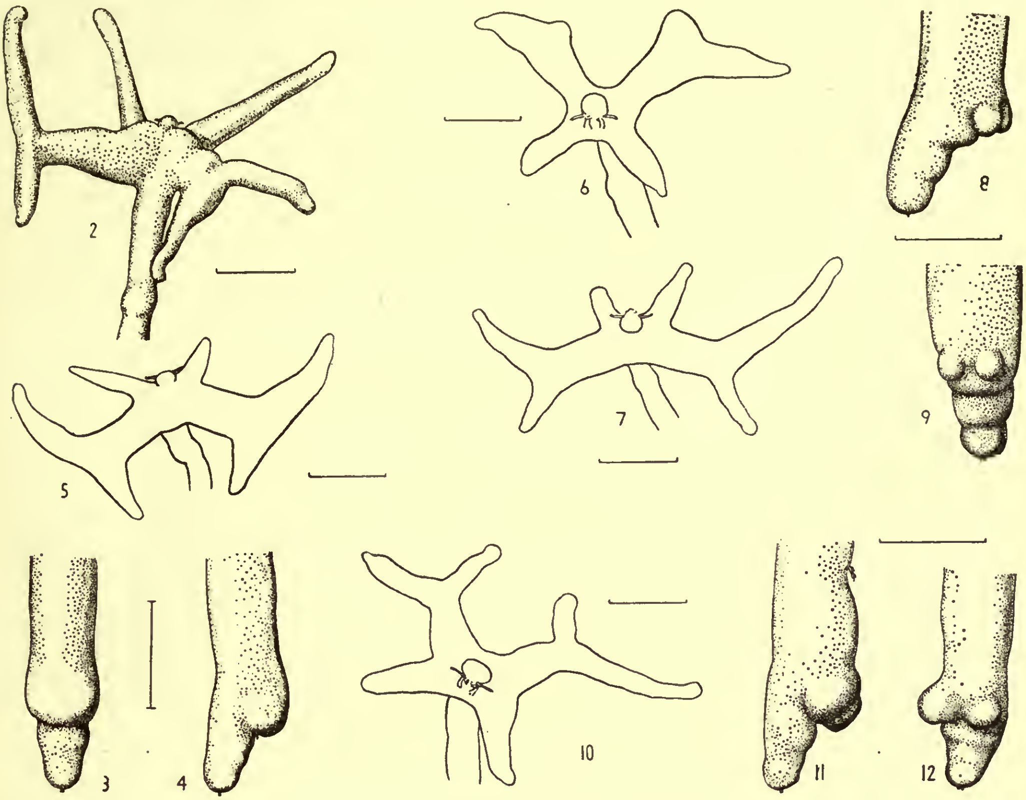
FIGS. 2–12.

1746 *Lernea tentaculis quatuor* Linnaeus, *Fauna Svecica*: 367, pl. 2.
1758 *Lernaea cyprinacea* Linnaeus, *Syst. Nat.*: 655.
1783 ,, ,, : Barbut, *Gen. Vermium*: 67, pl. 7, fig. 3.
1822 *Lerneocera cyprinacea* (Linnaeus) Blainville, *Journ. Phys.* **95**: 377.
1835 *Lernaeocera* ,, : Burmeister, *Nova Acta Leop. Carol.* **17**: 309, pl. 24 A, figs. 1–3.
1850 ,, ,, : Baird, *Brit. Entomost*: 343, pl. 35, fig. 13.
1904 ,, ,, : Hofer, *Handb. Fischkrankheit*, München: 144, fig. 95 and p. 119 [fide Pesta 1934].
1909 ,, ,, : Neresheimer, Brauer: *Süsswasserfauna Deutschl.* **11**: 77, fig. 326.
1913 ,, ,, (part): T. and A. Scott, *Brit. Parasit. Cop.*, Ray Soc. London: 154, pl. 50, figs. 4–5 [not figs. 1–3].
1917 *Lernaea cyprinacea*: Wilson, *Proc. U.S. Nat. Mus.* **53**: 4, 39.
1918 ,, ,, : Wilson, *Bull. U.S. Bur. Fish.* **35**: 193, 196, pl. 15, fig. 86.
1925 ,, (*Lernaeocera*) *elegans*: Leigh-Sharpe, *Parasitology*, **17**: 245, text-figs. 1–5.
1927 ,, *elegans*: Nakai, *J. Fish. Inst. Tokyo*, **23**: 39, pls. 2–4, text-figs. 1–7.
1927 ,, *cyprinacea*: Okada, *Annot. Zool. Jap. Tokyo*, **11**: 185, text-figs. 1–2.
1928 ,, *elegans*: Matsui and Kumada, *J. Fish. Inst. Tokyo*, **23**: 101, pls. 5–7.
1932 ,, *cyprinacea*: Monod. *Ann. Parasit. hum. comp.* **10**: 362, text-figs. 8 H, 11, 12.
1933 ,, ,, : Gurney, *Brit. Fresh-water Cop*, Ray Soc. Lond. **3**: 338 ,text-figs. 1969, 1971–1983.
1933 ,, *carassii* Tidd, *Ohio J. Sci.* **33**: 465, pl., figs. 1–8.
1934 ,, *cyprinacea*: Markewitsch, *Ann. Mus. zool. polon.* **10**: 234, pl. 45, fig. 8.
1934 ,, ,, : Pesta, *Tierwelt Deutschl.* **29**: 42, text-fig. 25.
1937 ,, ,, : Markewitsch, *Cop. Parasit. Binnengewäss. U.S.S.R.*, Kiev: 98, pl. 8.
1937 ,, ,, : Wagler, *Tierwelt Mitteleuropas*, Crust. **2**, 2a: 179, text-fig. 542.
1939 ,, ,, : Yamaguti, *Vol. Jubil. Prof. S. Yoshida* **2**: 475, pl. 30, figs. 156–165.

The material in the British Museum consists of two specimens found by Dr. Gurney on a specimen of *Carassius carassius* (L.) from Sweden in the Museum fish collection; a specimen from Canon Norman's collection which was labelled '*L. esoscina* from Prof. Heller' (this specimen is unfortunately without record of host or locality); thirty or more specimens from Japan presented by Dr. Gurney, and finally a few microscope slides of the type specimens of *L. elegans* presented by Mr. Leigh-Sharpe.

I have little to add to the excellent descriptions and figures given by many of the authors listed above, Gurney (1933) in particular; the shape of the anchor is, however, rather more variable than these descriptions indicate. The most typical arrangement is that of the Swedish specimen (Fig. 2), if the right dorsal arm which is distorted is ignored; the arms are all rather long and slender and the dorsal arms are T-shaped. This is the arrangement shown in nearly all figures of European specimens from Linnaeus, 1746 to Monod, 1932, and Gurney, 1933. Very few of the Japanese specimens are quite like this, there is a tendency for the dorsal arms to be Y-shaped (Figs. 5–7), and the posterior fork of the Y is often reduced. Prof. Heller's specimen (Figs. 10–12) of unknown origin is very like the Japanese specimens . The pregenital

prominence of *L. cyprinacea* is generally described as 'simple or only slightly indented' (Wilson, 1918, p. 193, key). It is simple in the Swedish specimens (Figs. 3 and 4). The Japanese specimens have a distinctly double pregenital prominence (Figs. 8 and 9). Prof. Heller's specimen again agrees with the Japanese specimens



FIGS. 2–12. *Lernaea cyprinacea* Linnaeus

Figs. 2–4, specimen from Sweden; Fig. 2, dorsal view of anchor; Fig. 3, ventral view of pregenital prominence and abdomen; Fig. 4, lateral view of the same; Figs. 5–9, specimens from Japan; Figs. 10–12, specimen from Prof. Heller. The line near each figure is 1 mm. drawn to the same scale.

rather than with the Swedish ones. Markewitsch (1937) also gives a figure of a specimen with a bilobed pregenital prominence, but he does not say from what part of the U.S.S.R. it came. None of the characters of *L. elegans* given by Leigh-Sharpe are valid for distinguishing between the Japanese form and the European. No 'auricular expansions' are now visible on the specimen from which Leigh-Sharpe's Fig. 3 was based; possibly the artist saw some folds of chitin. In this figure are shown what are called 3-segmented uncinate thoracic appendages, but an examination of the specimen shows that these are not appendages at all but are the badly fixed internal tissues which can be seen only by focusing well below the surface of the body, as Monod (1932) has already pointed out. Leigh-Sharpe's types of *L. elegans* are the same form of *L. cyprinacea* as the Japanese specimens I have seen.

I have looked at the appendages of the Swedish and Japanese specimens with some care, but have been unable to find any difference, the setation of the legs is precisely the same in both (Table 1). The positions of the legs on the body of five Japanese specimens were measured; there was considerable variation, particularly of the anterior legs, but the positions of the five pairs of legs do not enable the Japanese and European specimens to be separated from one another. The positions of the five legs were 6–9, 16–20, 42–45, 73–74, and 90–92 per cent. of the total body length distant from the most anterior part of the head, respectively.

There is little doubt that *L. carassii* Tidd is the Japanese or *elegans* form of *L. cyprinacea.*

Lernaea barnimiana (Hartmann)

FIGS. 13–28

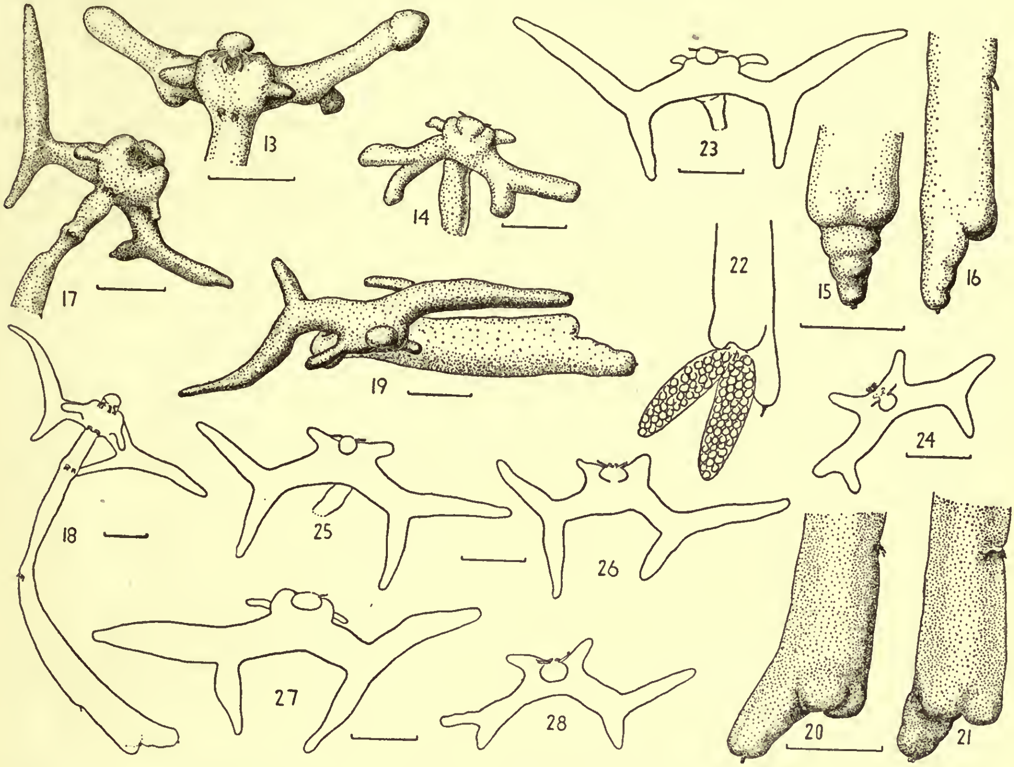
1865 *Lernaeocera barnimiana* Hartmann, *Naturges.-med. Skizze Nillander*: 206.
1870 ,, *barnimii* Hartmann, *Arch. Anat. Phys. Wiss. Med.* **1870**: 726, pls. 17–18.
1871 ,, ,, : Hartmann, *S. B. naturf. Fr. Berl.*: 60.
1914 ,, *temnocephala* Cunnington, *Proc. Zool. Soc. Lond.* **1914**: 827, pl. 1, figs. 8–9, text-fig. 1 c.
1917 *Lernaea barnimii*: Wilson, *Proc. U.S. Nat. Mus.* **53**: 38.
1918 ,, *temnocephala*: Wilson, *Bull. U.S. Bur. Fish.* **35**: 193, 196, pl. 15, fig. 87.
1918 ,, *barnimii*: ibid.: 193, 196, pl. 15, fig. 94.
1940 ,, *temnocephala*: Brian, *Boll. Idrobiol. Caccia Pesca,* **1**: 50, pl., figs. A–F.
1944 ,, *barnimiana*: Capart, *Bull. Mus. Hist. nat. Belg.* **20** (24): 2, text-fig. 1.

Several specimens of this species were taken from a fish, *Labeo forskalii* Rüppell, caught in Lake Edward by Dr. E. B. Worthington in 1931. The heads of the parasites were buried in the flesh of the head and inside the mouth of the fish. The Museum also possesses the single specimen on which Cunnington founded *L. temnocephala.* Thanks to the kindness of Dr. Capart I have seen three of the specimens he described from the Belgian Congo.

The length of the adult female, judging from the literature, ranges from 7 mm. to 12 mm. (Capart's 1944 figs.); Hartmann's 1870 record of a range of from 10 mm. to 14 mm. may include the anterior arms of the anchor in the length. The British Museum specimens range from 8·2 mm. to 10·8 mm. in length.

The positions of the five pairs of legs of seven of the Lake Edward specimens give the following ranges measured in percentages of the total body length: 7·2–9·8, 19–24, 41–51, 73–79, and 89–92 per cent. respectively. The positions of the legs on the specimens kindly lent me by Dr. Capart agree, but two other specimens which he figures (Capart, 1944, fig. 1, A and E) appear to have the first and second legs a little farther forward; this may, however, be owing to the foreshortening which is inevitable when curved specimens are drawn. Hartmann's (1870) drawings are not very reliable and I attach no importance to the fact that the position of the fourth pair of legs in his Fig. 1 is only 65 per cent. of the body length from the anterior. The positions for Cunnington's type of *L. temnocephala* are 8, 18, 44, 79, and 92 per cent. respectively. The variations in the positions of the legs seems to be quite independent of the size of the specimen, i.e. there is no heterogony with respect to this character.

The torsion of the specimens I have seen was variable; that between successive pairs of legs never exceeded 90° and was usually much less. It could be either sinistral or dextral and frequently changed its direction. The total torsion of the whole body was not more than 120° in any of the twelve specimens examined.



FIGS. 13–28. *Lernaea barnimiana* (Hartmann).

Figs. 13–16, Cunnington's specimen from L. Tanganyika, named by him *temnocephala*; Fig. 13, ventral view of anchor; Fig. 14, dorsal view; Fig 15, ventral view of abdomen and pregenital prominence; Fig. 16, lateral view of the same. Figs. 17–28, specimens from L. Edward. Fig. 17, ventral view of anchor; Fig. 18, ventral view of another specimen; Fig. 19, anterior view of the latter; Figs. 20 and 21, posterior end of this specimen; Fig. 22, posterior end of a specimen with egg-sacs; Figs. 23–28, anchors of other specimens from L. Edward, all from the same fish. The line near each figure is 1 mm. drawn to the same scale.

The arms of the anchor are rather variable in shape and arrangement, as Capart (1944) has shown. The most usual arrangement is for the part between the head and the first legs to be swollen and more or less globular. The ventral arms are simple in shape and very short. The usual arrangement is for the ventral arms to be directed outwards; this was so in all the Lake Edward material, in Cunnington's specimen from the Nile, and in most of Capart's material from the Belgian Congo. In some of Capart's specimens and also in the figure accompanying Hartmann's description (Hartmann, 1870, fig. 1), on the other hand, the ventral processes are directed anteriorly. With regard to the bifurcating dorsal arms, Hartmann's figure shows both branches equal to one another and both diverging slightly away from the body; but in his description he says that the anterior branch is the longer of the two and

is the more outwardly directed. The normal condition seems to be for the anterior branch to diverge widely from the body while the posterior branch is directed slightly inwards (Figs. 17, 18, 23, &c.). The angle between the two branches is normally an open and continuous curve; but sometimes as in Figs. 25, 27, 28, &c. there is a more or less distinct angle. The Y-shaped condition of the arms of the *temnocephala* holotype (Fig. 14) is unusual but within the range of variation of *L. barnimiana*.

The pregenital prominence is distinct and bilobed (Figs. 15, 16, 20, and 21); but from some aspects it may appear to be a single broad process.

The abdomen is distinctly 3-segmented and may continue the line of the body or be set at an angle. Each segment is a little smaller than the preceding one. Hartmann does not describe the abdomen of his specimens, and his figure and those of Brian (1940) are of little value in this respect. Cunnington's *temnocephala* specimen (Figs. 15 and 16) is normal.

The setation of the legs is the same as that of *L. cyprinacea* (Table 1, p. 4). I have cleared Cunnington's type of *temnocephala* with potassium hydroxide, and this has got rid of the twists and distortions he mentions and has enabled me to examine the setation of its legs; and as with the other characters investigated I can find no difference between this specimen and the Lake Edward specimens and I have no hesitation in placing *L. temnocephala* (Cunnington) in the synonymy of *L. barnimiana*, as Capart (1944) has already suggested.

Lernaea piscinae sp. nov.

Figs. 29–34

Holotype, Reg. No. 1949.8.14.1, and many paratypes, all females, in the British Museum. The parasites were found heavily infesting a Cyprinid fish, *Hypophthalmicthys nobilis* (Richardson) cultivated by the Chinese on a fish farm at Singapore. Four fish heavily infested with the parasites, over 50 per fish, were presented to the Museum by Mr. W. Birthwhistle in 1929. Length of holotype 10·4 mm.; the length of 10 paratypes ranged from 9·7 mm. to 12·4 mm. The positions of the five pairs of legs of these eleven specimens were 5–7, 13–14, 31–38, 69–74, and 91–93 per cent. of the total length from the most anterior part of the head. All the specimens of this species were very much alike; seven out of the eleven specimens had a curve between legs 2 and 3 as in Fig. 29. Three of the remainder were straight and the other had an additional bend between legs 1 and 2.

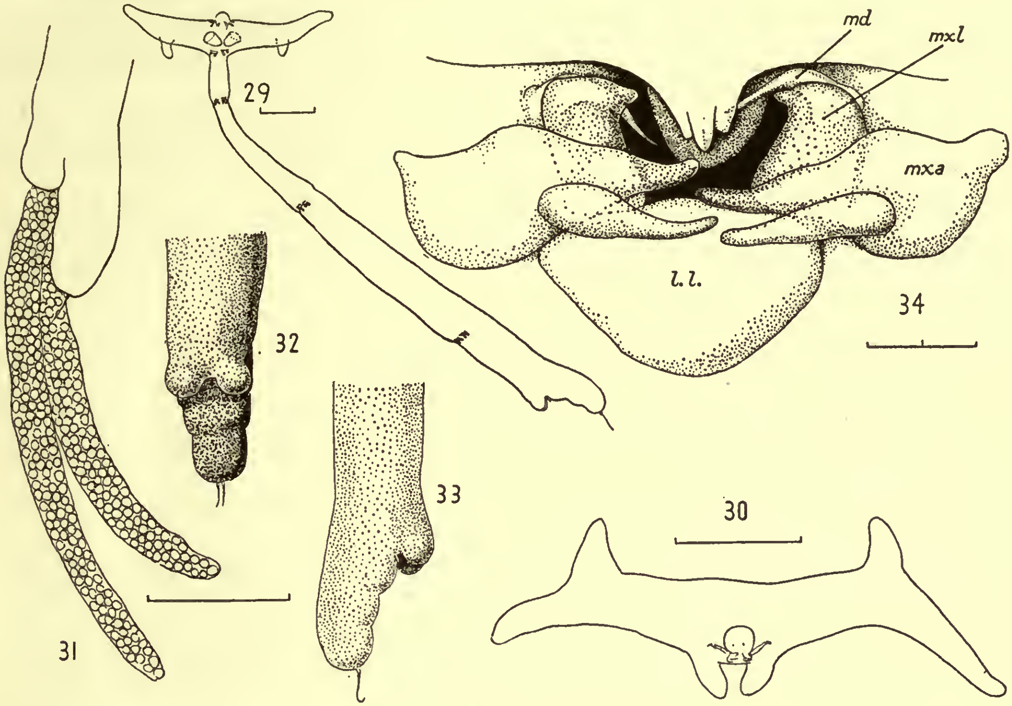
The main part of the anchor forms a bar set at right angles to the body like the cross-bar of a T (Figs. 29 and 30). The middle of the bar is considerably thicker than the part of the body joined to it, and tapers gradually towards the ends, which are also curved slightly in an antero-ventral direction. From about the middle of each half of the cross-bar there is a short dorsal process. There is also a pair of ventral processes between the head and the legs 1; these are separated by a distance about equal to the width of the head and are directed slightly inwards towards one another.

Except for slight swellings at the positions of the legs the body increases in thickness very gradually from before backwards.

The abdomen (Figs. 32–33) makes a slight angle with the body; it is nearly 1 mm.

long and less than ½ mm. wide. Ventrally it is distinctly 3-segmented; but the dorsal profile forms an even, continuous curve.

The pregenital process is double, the two lobes being small but well defined and quite separate from one another.



FIGS. 29–34. *Lernaea piscinae* sp. nov.

Fig. 29, ventral view of holotype; Fig. 30, anterior view of anchor; Fig. 31, lateral view of posterior end of a paratype with egg-sacs; Fig. 32, ventral view of abdomen and pregenital prominences of holotype; Fig. 33, lateral view of the same; Fig. 34, mouth and associated appendages. *l.l.*, lower lip; *md.*, mandible; *mxa.*, maxilla; *mxl.*, maxillule. The line near each figure is 1 mm. drawn to the same scale except that near fig. 34 which is 0·02 mm.

The egg-sacs (Fig. 31) are very long, about 4 mm., three-quarters of their length projecting beyond the tip of the abdomen.

The setation of the legs is the same as in *L. cyprinacea* (Table 1).

The mouth parts (Fig. 34), as far as I was able to make out, are the same as for other species.

Lernaea diceracephala (Cunnington)

FIGS. 35–39

1914 *Lernaeocera diceracephala* Cunnington, *Proc. Zool. Soc. Lond.* **1914:** 824, pl. 1, figs. 1–3, text-fig. 1 A.
1917 *Lernaea diceracephala*: Wilson, *Proc. U.S. Nat. Mus.* **53:** 38.
1918 ,, ,, : Wilson, *Bull. U.S. Bur. Fish.* **35:** 192, 194, pl. 15, fig. 90.
1944 ,, ,, : Capart, *Bull. Mus. Hist. nat. Belg.* **20** (24): 7.

Holotype, Reg. No. 1914.12.2.1, and one paratype in the British Museum; I have

selected the more perfect of the two specimens as the holotype. These are the only specimens known and were taken from the gill arches of a large *Clarias mossambicus* Peters, caught at Sumbu, Lake Tanganyika, by Dr. Cunnington in 1904. Capart (1944) includes the species in his paper because part of Lake Tanganyika lies in the Belgian Congo.

Cunnington's description of the two specimens is very good; but he describes the left arm as being complete in the better specimen when in fact the tip has been broken off.

The length of the holotype measured as if straightened out is 9·1 mm. The five pairs of legs come in positions 10, 23, 50, 71, and 92 per cent. of the total length from the most anterior part of the head.

I have made drawings of the two specimens which I hope are an improvement on Cunnington's photographs, and which show how similar to one another are the bends and constrictions in the body.

Lernaea bagri sp. nov.

FIGS. 40–43

Holotype, Reg. No. 1949.8.14.9, and over two dozen paratypes, all females, in the British Museum.

The copepods were taken from *Bagrus meridionalis* in Lake Nyasa by Miss R. H. Low, 14 Aug. and 22 Sept. 1946.

The length of the holotype is 12·1 mm.; that of twenty-four adult females carrying egg-sacs ranged from 9·9 mm. to 14·2 mm.

The body of a few of the slender, young-looking specimens is straight, but usually it is curved as shown (Fig. 40), and in these there is a torsion which in this species nearly always changes its direction. In all the specimens I have examined for this purpose the torsion is first sinistral and then dextral. In the holotype, for example, the torsion between legs 1 and 2 is 40° sinistral, between legs 2 and 3 it is 80° dextral, and between legs 3 and 4 it is a further 50° dextral, after which there is no further torsion. The resultant torsion between the head and the abdomen is about 90° dextral.

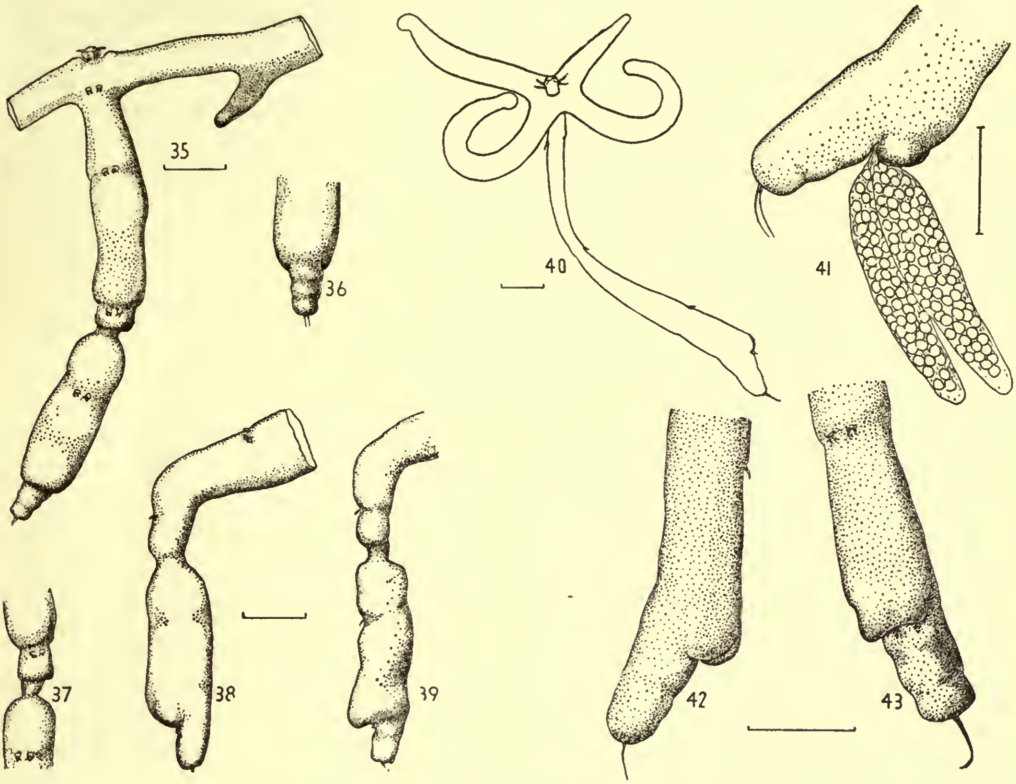
The arms of the anchor are heavily chitinized, in contrast to those of the next species to be described, *L. tilapiae*, and lie in a plane approximately at right angles to the body. The head is placed centrally over the cross formed by the four arms. The ventral arms are straight and the dorsal ones are curved towards them. There is a tendency for each arm to end with a rounded knob.

The positions of the legs are rather variable in this species. Six specimens were examined, and the positions of legs 1 to 5 gave the following ranges respectively: 7–10, 18–22, 42–52, 73–78, and 90–93 per cent. The setation of the legs is the same as that of *L. cyprinacea* (Table 1).

The abdomen (Figs. 41–3) is set at a slight angle to the line of the body; it is straight and slightly tapering; the three segments are very indistinctly separated.

The pregenital prominence is bilobed. Sometimes the lobes are prominent and bulge laterally beyond the greatest width of the body, but usually, as in the holotype, they are not very prominent from the ventral aspect (Fig. 43).

The egg-sacs (Fig. 41) are about $2\frac{1}{2}$ mm. long and $\frac{1}{2}$ mm. wide at their greatest width, which lies at about the proximal third of the length.



FIGS. 35–39. *Lernaea diceracephala* (Cunnington).

Fig. 35, ventral view of holotype; Fig. 36, dorsal view of abdomen; Fig. 37, constriction between legs 3 and 4 from a slightly different aspect from that of Fig. 35; Fig. 38, lateral view of paratype; Fig. 39, similar view of part of holotype.

FIGS. 40–43. *Lernaea bagri*, sp. nov.

Fig. 40, dorsal view of holotype; Fig. 41, lateral view of abdomen and egg-sacs of a paratype; Fig. 42, lateral view of abdomen and pregenital prominences; Fig. 43, ventral view of the same. The line near each figure is 1 mm. drawn to the same scale.

Lernaea tilapiae sp. nov.

FIGS. 44–46

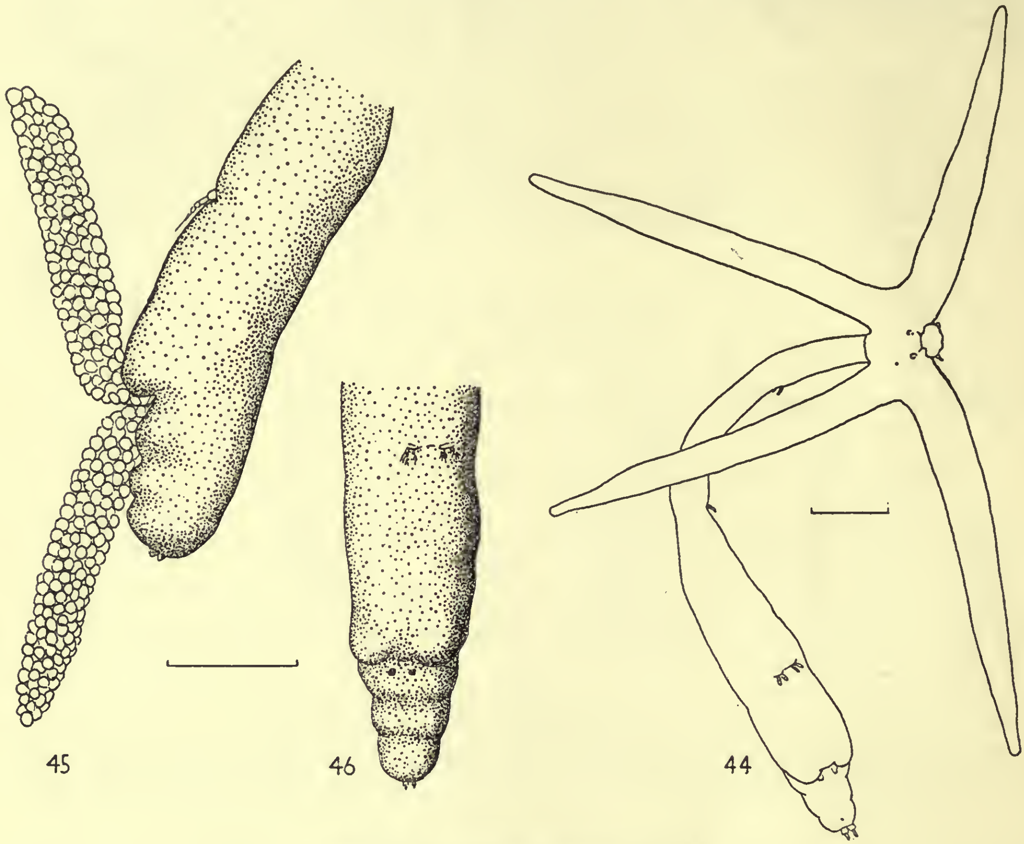
Holotype, Reg. No. 1949.8.14.17, and a few paratypes, all females, in the British Museum.

The parasites were collected by Miss R. H. Low from Lake Nyasa and were taken from the mouth and gills of *Tilapia squamipinnis* Günther and *T. lidole* Trewavas caught in Lake Nyasa 22 Nov. 1946.

The length of the holotype measured from the front of the head to the tip of the

abdomen is 9·2 mm. Five other females bearing egg-sacs ranged from 7·5 mm. to 11 mm. in length.

The body is comparatively slender from the head to as far as legs 3 and is usually curved here, so that the anterior part of the body is at right angles to the broad part behind legs 3 (Fig. 44). In the holotype the torsion is dextral 45° between legs 2 and 3,



FIGS. 44–46. *Lernaea tilapiae* sp. nov.

Fig. 44, dorsal view of holotype; Fig. 45, lateral view of abdomen, pregenital prominence, and egg-sacs; Fig. 46, ventral view of the same without egg-sacs. The line near each figure is 1 mm. drawn to the same scale.

dextral 90° between legs 3 and 4, and dextral a few degrees beyond legs 4, the total torsion being dextral through about 140°. The only torsion in one of the paratypes is a sinistral one of 45° between legs 3 and 4.

The anchor bears four long straight slender arms as figured (Fig. 44); these lie in a plane nearly parallel to that of the body; the posterior pair are directed backwards and are only slightly divergent; the anterior pair diverge widely, with the head placed in the angle between them. The four arms of the anchor are about equal in length to one another and more than half the length of the body. They are only lightly chitinized and are much softer than those of the last species described, *L. bagri*.

The legs come in positions 8, 25, 50, 77, and 90 per cent. of the body length from the anterior end. The setation of legs 1 to 4 is the same as for *L. cyprinacea* (Table 1, p. 4).

The abdomen is divided into three segments by transverse ventral constrictions which give it a characteristic profile (Fig. 45). The dorsal profile of the abdomen is slightly arched.

The pregenital prominence is bilobed; the two lobes overhang the abdomen slightly, but their ventral surface is in line with that of the body in front (Fig. 45).

The egg-sacs are about 2·5 mm. long and 0·5 mm. wide, slightly tapering towards each end. Miss Low records that in life the parasite is brown in colour and the eggs are jade-green.

Lernaea barilii sp. nov.

FIGS. 47–60

Holotype, Reg. No. 1949.8.14.21, and about 10 paratypes, all females, in the British Museum.

The parasites were taken on a large specimen (500 mm. long) of *Barilius microlepis* Günther from Lake Nyasa by Dr. Christy in 1925, a piece of the flank of the fish with the copepods embedded being preserved together with a note to the effect that there were more parasites on the tongue, &c. I have only seen the specimens from the flank.

The length of the holotype is 8·3 mm. with the positions of legs 1 to 5 at 8·4, 20, 47, 77, and 92 per cent. of the total body length from the anterior end respectively. The positions on paratype Reg. No. 1949.8.14.24 are 8, 19, 47, 77, and 93 per cent. The setation of the legs is the same as in *L. cyprinacea* (Table 1, p. 4).

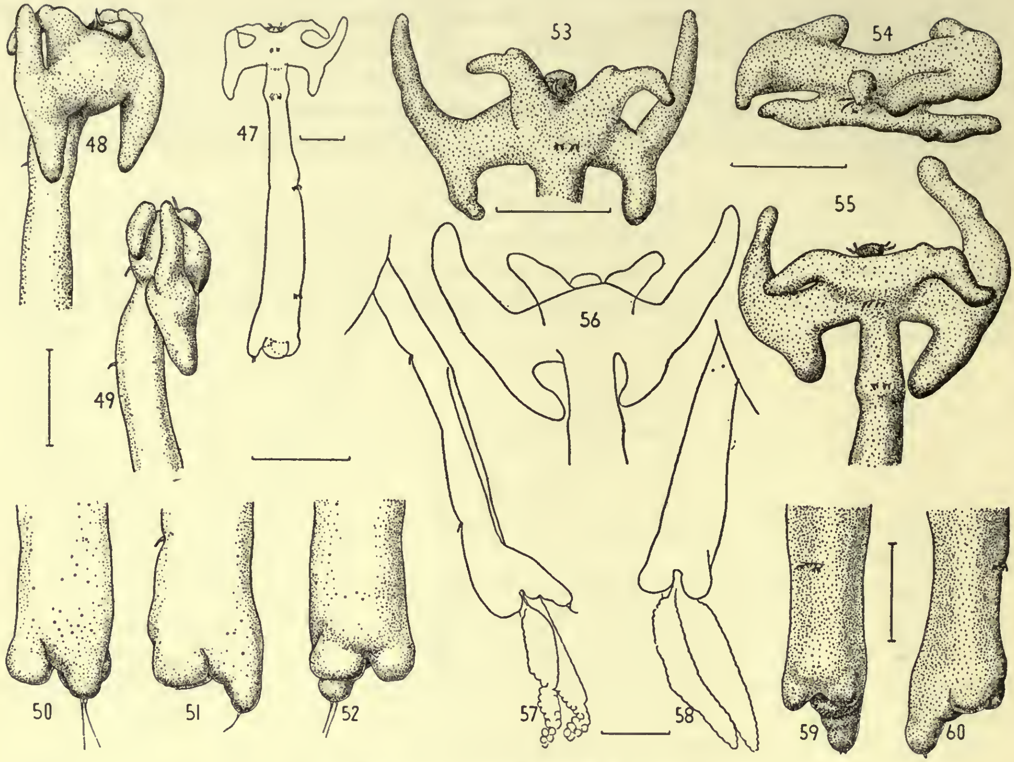
The body is straight and short, widest at the posterior end. In the two specimens which were examined in detail the torsion was about 80°. In the holotype most of the torsion was between legs 2 and 3, and in the paratype examined it was between legs 3 and 4; it was sinistral in the holotype and dextral in the paratype.

The arrangement of the anchor is best understood with reference to Figs. 47–49 and 53–55. There are a pair of lateral T-shaped arms with the cross-bar of the T running more or less parallel to the body; the basal part of these arms is short and thick. Anterior and ventral to the dorsal arms are a pair of simple arms directed outwards, with in nearly all cases a small knob facing anteriorly.

The pregenital prominences are very large and distinctly separated from one another; they reach almost to the end of the abdomen in some specimens (Figs. 40, 50–52, 57–60).

The abdomen, particularly the part composed of the last two segments, is very small and set at an angle to the body. All three segments are clearly marked off from one another ventrally; the first is very much broader than the other two (Figs. 51 and 60).

The egg-sacs of the holotype were about 2.75 mm. long, broadest in the middle and tapering towards each end (Fig. 58).



FIGS. 47–60. *Lernaea barilii* sp. nov.

Fig. 47, ventral view of holotype; Fig. 48, dorso-lateral view of anchor; Fig. 49, lateral view of the same; Fig. 50, dorsal view of posterior end of holotype; Fig. 51, lateral view of the same; Fig. 52, ventral view of the same; Fig. 53, ventral view of anchor of a paratype; Fig. 54, anterior view of another paratype; Fig. 55, ventral view of the same; Fig. 56, anchor of a specimen drawn *in situ* by clearing in benzyl alcohol; Fig. 57, lateral view of specimen with egg-sacs before removing from the fish (the specimen has shrunk and collapsed dorsally); Fig. 58, ventral view of holotype with egg-sacs before treatment with hydroxide; Fig. 59, ventral view of the posterior end of a paratype; Fig. 60, lateral view of the same. The line near each figure is 1 mm. drawn to the same scale.

Lernaea palati sp. nov.

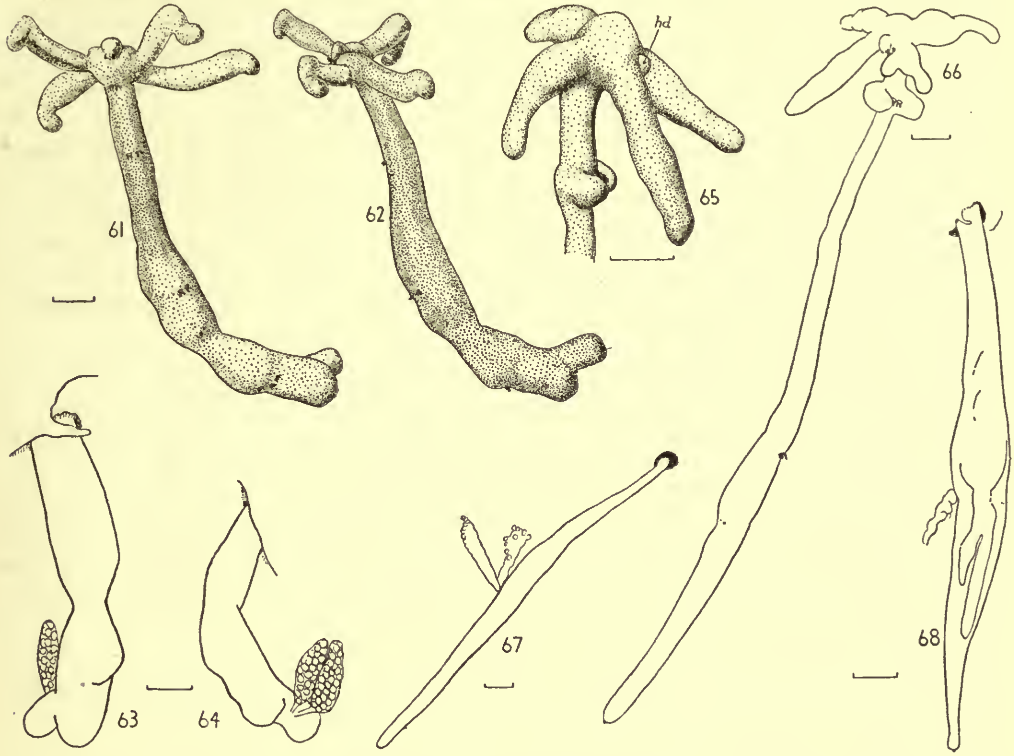
FIGS. 61–64

Holotype, Reg. No. 1949.8.14.26 in the British Museum. The single specimen on which this species is based was from the roof of the mouth of a fish, *Haplochromis chrysonotus* (Boulenger) from Vua on Lake Nyasa, collected by Dr. Christy in 1925. The hind end of the parasite projected through a gill slit and was visible externally.

The length of the specimen, allowance being made for bends, is 12·7 mm. The body from the first pair of legs to half-way between legs 2 and 3 is cylindrical, about 0·7 mm. thick; the section containing legs 3 is broader, about 1·2 mm. across; there is a waist between legs 3 and 4; the body bends backwards and to the left here and bulges again to a thickness of 1·2 mm. in front of legs 4.

The abdomen is tilted dorsally at an angle of about 45°; it is a simple cylinder rounded at the end about 1 mm. long and 0·7 mm. broad without any sign of segmentation.

The five pairs of legs are placed in positions 8·7, 26, 55, 80, and 93 per cent. of the body length from the anterior end. The setation is the same as that of *L. cyprinacea* (Table 1, p. 4). There is little torsion.



Figs. 61–64. *Lernaea palati* sp. nov.

Fig. 61, ventral view of holotype; Fig. 62, lateral view; Fig. 63, holotype embedded in roof of mouth of fish; Fig. 64, another view of the same showing egg-sacs.

Figs. 65–68. *Lernaea longa,* sp. nov.

Fig. 65, lateral view of holotype showing anchor and swelling by legs 2. *hd*, head; Fig. 66. A paratype with the left ventral arm of the anchor distorted; Figs. 67 and 68, the externally visible parts of two other specimens embedded in the fish. The line near each figure is 1 mm. drawn to the same scale.

The anchoring arms (Figs. 61 and 62) are four in number, of medium length and uniform thickness, each with a bend or a kink near the end. The ventral pair is directed slightly forwards and the dorsal pair backwards to the same extent.

The head is not in line with the body, but inclined towards the angle between the ventral arms of the anchor.

The egg-sacs are comparatively short and broad, being about 1·5 mm. long and 0·5 mm. broad (Figs. 63 and 64).

Lernaea longa sp. nov.

FIGS. 65–68

Holotype, Reg. No. 1949.8.14.27, and half a dozen paratypes, all females, in the British Museum.

All the specimens were from a single specimen of *Lates niloticus* subsp. *longispinus* Worthington from Lake Rudolf, collected by Dr. E. B. Worthington in 1931. The parasites were embedded in the head and flanks of the fish.

The length of the holotype is 19 mm., with the five pairs of limbs in positions 6·3, 14, 36, 64, and 77 per cent. of the body length from the anterior end. Owing to the fact that the head is held ventrally between the ventral arms of the anchor, these measurements have been made from the most anterior part of the body, i.e. the central boss of the anchor. In paratype, Reg. No. 1949.8.14.29 (Fig. 66) the total length is 22 mm. with the legs in positions 5, 11, 32, 59, and 71 per cent. of the body length.

The body is long and slender with a conspicuous swelling in the region of legs 2, and from this swelling a pair of rounded processes project ventrally with the second pair of legs between them. There are slight swellings in the regions of legs 3 and 4.

Two examples will suffice to show how the torsion varies and may change its direction in this species. In the holotype the total torsion is a sinistral one of 110°, made up of a dextral torsion of 10° between legs 2 and 3 and a sinistral torsion between legs 3 and 4. In paratype Reg. No. 1949.8.14.29 the total torsion is a dextral one of 20°; this is the resultant of a sinistral torsion of 45° between legs 1 and 2, and of 135° between legs 2 and 3, followed by a dextral torsion of 90° between legs 3 and 4, and of 110° between legs 4 and 5.

The abdomen is very long, about a quarter of the total body length; it is in line with the rest of the body and tapers gradually to a rounded tip without any indications of segmentation. The pregenital prominence is ill defined.

The anchor has normally four simple more or less cylindrical arms as shown in Fig. 65. One of the ventral arms of specimen Reg. No. 1949.8.14.29 is branched, but this is evidently an abnormality probably caused by its meeting an obstruction during its growth into the flesh of the fish (Fig. 66). The ventral arms are about 5 times as long as they are broad and are directed backwards at an angle of about 45° to the body. The dorsal arms are a little shorter and are directed more nearly at right angles to the body.

The head is placed on the ventral side of the anchor in the fork between the ventral pair of arms.

None of the specimens had complete egg-sacs; the most complete was 3 mm. long, with a maximum width of 0·6 mm.

Lernaea haplocephala (Cunnington)

1914 *Lernaeocera haplocephala* Cunnington, *Proc. Zool. Soc. Lond.* **1914:** 826, pl. 1, figs. 4–7, text-fig. 1 B.
1917 *Lernaea haplocephala*: Wilson, *Proc. U.S. Nat. Mus.* **53:** 38.
1918 ,, ,, : Wilson, *Bull. U.S. Bur. Fish.* **35:** 193, 195, pl. 15, fig. 92.
1920 ,, ,, : Wilson, *Bull. Amer. Mus. Nat. Hist.* **43** (1): 5, pl. 3, figs. 20–22.

1923 *Lernaeocera bichiri* Kurtz, *S. B. Akad. Wiss. Wien.* **131**, Abt. 1: 332, pl. 2, figs. 1–11.
1927 *Lernaea haplocephala*: Brian, *Faune Colon. Fr.* **1**: 581, figs. 26–34.
1944 ,, ,, : Capart, *Bull. Mus. Hist. nat. Belg.* **20** (24): 7.

The British Museum possesses the twenty-seven specimens listed by Cunnington, from three species of *Polypterus* from Lake Tanganyika and the White Nile. I select as holotype the single specimen, Reg. No. 1914.12.2.3, taken from *Polypterus congicus* Boulenger collected from Lake Tanganyika by Cunnington himself and on which his description is largely based. *L. haplocephala* is probably the best known of the African species of *Lernaea* and has been found on several species of *Polypterus* in the White Nile, Belgian Congo, and Cameroons.

The species is easily recognized by the shape of the anchor and by the peculiar swelling in the region of legs 2; and it is unfortunate that Wilson (1920), in his eagerness to find characters in the appendages, should have added as a distinguishing character 'the small spherical terminal joint of the maxillipedes, with its four curved claws'. I have examined the maxillipedes of the holotype and of some of the paratypes and can find no distinguishing feature in them; they have five claws like every other species I have looked at. Wilson may have had a specimen with only four claws Brian describes and figures only three, but they are not easy to see and are difficult to count. There is, however, a character in which the appendages of *L. haplocephala* differ from those of all other species of *Lernaea* that I have been able to examine: there are only four setae on the terminal joints of the exopods of the first four pairs of legs (Table 2); other species have five setae here. The setation of these legs has been correctly figured by Kurtz and by Brian.

TABLE 2

Arrangement of the setae and spines on the legs of *Lernaea haplocephala*

		Leg 1	*Leg 2*	*Leg 3*	*Leg 4*
Exopod	spines	1.1.2	1.1.3	1.1.3	1.1.3
	setae	1.1.**4**	1.1.**4**	1.1.**4**	1.1.**4**
Endopod	spines	0.0.2	0.0.2	0.0.2	0.0.2
	setae	1.1.4	1.2.4	1.2.4	1.2.3

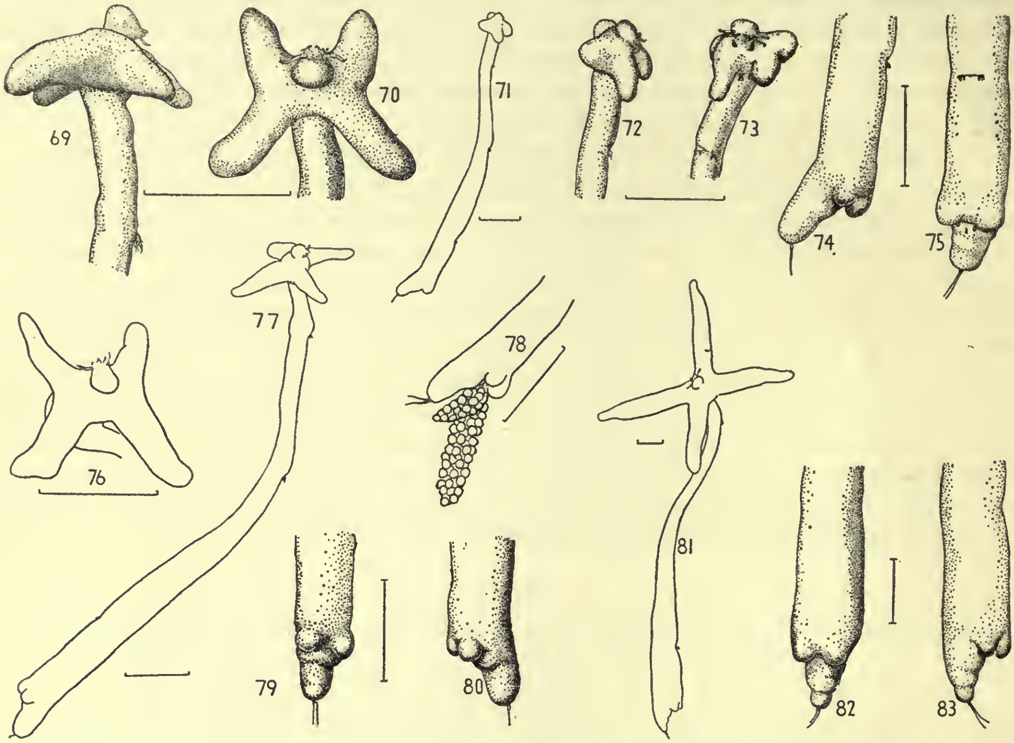
Lernaea lophiara sp. nov.

FIGS. 69–80

Holotype, Reg. No. 1949.8.14.34, and several paratypes, all females, in the British Museum. The holotype was from the dorsal fin of *Lethrinops lethrinus* (Günther) from Lake Nyasa. The paratypes included very similar specimens from the dorsal fins of the following species of fish, all from Lake Nyasa: *Haplochromis prostoma* Trewavas, *H.* sp. cf. *micrentodon* Regan, *Rhamphochromis lucius* Ahl, *Pseudotropheus tropheops* Regan, *Diplotaxodon argenteus* Trewavas, and also buried in the edge of the operculum of *Lethrinops praeorbitalis* Regan. Other paratypes which differ from the holotype only in having very short arms to the anchor were found in the dorsal fins of *Haplochromis breviceps* Regan and *Tilapia melanopleura* Dumeril. Specimens which I have left *in situ* and not examined but are presumably the same species were found in

the dorsal fins of *Haplochromis argyrosoma* Regan, *H. incola* Trewavas, *H. johnstoni* (Günther), and *H. nigritaeniatus* Trewavas.

The length of the holotype is 9·6 mm. with the legs in positions 6, 16, 42, 76, and 93 per cent. of the body length from the anterior end. The body is curved between legs 2 and 3, so that the axis of the anterior end of the body is approximately at



FIGS. 69–80. *Lernaea lophiara* sp. nov.

Fig. 69, lateral view of head and anchor of holotype from dorsal fin of *Lethrinops*; Fig. 70, anterior view of the same; Fig. 71, paratype Reg No. 1949.8.14.35 from dorsal fin of *Haplochromis*; Fig. 72, lateral view of anchor; Fig. 73, ventral view of the same; Fig. 74, lateral view of abdomen and pregenital prominences of the same paratype; Fig. 75, ventral view of the same; Fig. 76, anterior view of anchor of paratype Reg. No. 1949.8.14.45 from operculum of *Lethrinops*; Fig. 77, general view of this paratype; Fig. 78, posterior end with egg-sacs of paratype Reg. No. 1949.8.14.46 from operculum of *Lethrinops*; Fig. 79, ventral view of abdomen and pregenital prominences of paratype Reg. No. 1949.8.14.45; Fig. 80, lateral view of the same.

FIGS. 81–83. *Lernaea* cf. *lophiara*

Fig. 81, specimen from operculum of *Rhamphochromis* Reg. No. 1949.8.14.47; Fig. 82, ventral view of abdomen and pregenital prominences of this specimen; Fig. 83, lateral view of the same. The line near each figure is 1 mm. drawn to the same scale.

right angles to the posterior end. The total torsion of the holotype is a dextral one of about 145°; this is made up of a dextral torsion between legs 2 and 3 of 85° and a further dextral torsion of 60° between legs 3 and 4.

The lengths of seven paratypes range from 6·7 mm. to 9·8 mm., the positions of the five pairs of legs ranging from 5–6·5, 17–18, 42–47, 73–79, and 93–94 per cent. of the body length from the anterior end respectively. Only in two specimens, one of

them the holotype, is the torsion of the body more than 90°. There is nearly always some torsion, however, and also a curvature in the region of legs 2 and 3.

The anchor has four simple arms. In most of the specimens (Figs. 69, 70, 76, 77), including the holotype from the dorsal fin of *Lethrinops praeorbitalis* and paratype Reg. No. 1949.8.14.45 from the operculum of the same fish, the dorsal arms are a little longer than the ventral ones and tend to splay outwards towards the ends. In two other specimens (Figs. 71–73) from dorsal fins, one from *Haplochromis breviceps*, the other from *Tilapia melanopleura*, the arms of the anchor are very short.

The pregenital prominence is double in all specimens except one which is the smallest examined and measures 6·7 mm. in length.

The setation of the legs is the same as that of *L. cyprinacea* (Table 1, p. 4).

The egg-sacs are spindle-shaped and two or three times as long as the abdomen.

Lernaea sp. cf. *lophiara*

FIGS. 81–83

A fish of the species *Rhamphochromis lucius* Ahl bore three parasites: one on the fin is a typical example of *Lernaea lophiara*, the other two, one on the flank and the other on the operculum, are considerably larger than normal for that species and have very much larger arms to the anchor. The shape of the abdomen is also rather different. It may be found that these two specimens belong to a new species, but the comparatively well-developed condition of the arms of the anchor might be due to there being more space for them to grow in the body of the fish than there is in the fin. Against this, however, is the fact that the specimens of *L. lophiara* from the operculum of *Lethrinops praeorbitalis* do not differ in the size of the anchor or in other respects from specimens from the fins.

The lengths of the two specimens from the flank and operculum are 14·4 mm. and 13·7 mm. respectively. The anchor of the shorter specimen is damaged, that of the larger is shown in Fig. 81. The last segment of the abdomen is very small in these two specimens, the abdomen as a result being much more conical in shape than is typical for *L. lophiara* (Figs. 82–83). The positions of the five pairs of legs of the larger specimen are 5, 17, 46, 73, and 94 per cent. of the body length from the anterior end respectively. The setation of the legs is the same as that of the other specimens.

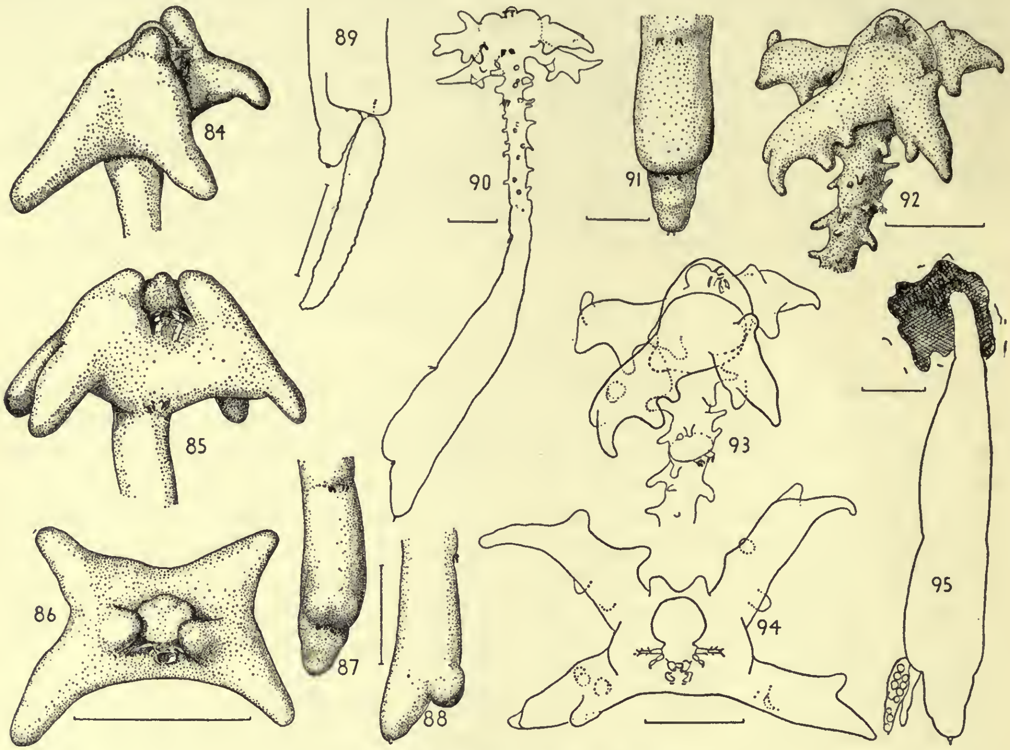
Lernaea bistricornis sp. nov.

FIGS. 84–88

Holotype Reg. No. 1949.8.14.49 in the British Museum. This species has to be described from a single specimen found at the base of a pelvic fin of *Cardio-pharynx schoutedeni* Poll from Lake Tanganyika.

The length of the holotype is 8·7 mm. The body is curved evenly into a semicircle, and there is a sinistral torsion of about 90°. The positions of the five pairs of legs are 8, 21, 45, 76, and 94 per cent. of the body length from the anterior end respectively. The setation of legs 1 and 2 cannot be seen, but that of legs 3 and 4 is the same as that of *L. cyprinacea* (Table 1, p. 4).

The anchor (Figs. 84–86) has six short, blunt processes, three on each side. There is a dorsal pair and a ventral pair, both of which are directed outwards and backwards. These are similar to those of some specimens of *L. lophiara*; but in addition



FIGS. 84–88. *Lernaea bistricornis* sp. nov.

Fig. 84, latera lview of anchor; Fig. 85, ventral view; Fig. 86, anterior view of the same; Fig. 87, ventral view of abdomen and pregenital prominence; Fig. 88, lateral view of the same.

FIG. 89. *Lernaea barbicola* Leigh-Sharpe. Abdomen, pregenital prominence, and egg-sac.

FIGS. 90–95. *Lernaea tuberosa* sp. nov.

Fig. 90, ventral view of holotype; Fig. 91, abdomen and pregenital prominence; Fig. 92, lateral view of anchor; Fig. 93, the same seen as a transparent object; Fig. 94, anterior view of anchor; Fig. 95, the visible part of the parasite protruding from the hole in the side of the fish. The line near each figure is 1 mm. drawn to the same scale.

there is a pair of small knobs on each side of the head which reach over as if to protect it.

The pregenital prominence is well defined (Figs. 87–88), but appears to be simple. The abdomen is of normal length, rather tapering, and without signs of segmentation.

The egg-sacs are spindle-shaped and about 1·3 mm. long.

Lernaea barbicola Leigh-Sharpe

FIG. 89

1930 *Lernaea* (*Lernaeocera*) *barbicola* Leigh-Sharpe. *Parasitology* **22**: 334, text-figs. 1–6.

Mr. Leigh-Sharpe has kindly presented the holotype Reg. No. 1949.8.14.50 of this species mounted on a microscope slide to the Museum. It was from the tail of a species of *Barbus* from the Transvaal.

Unfortunately the arms of the anchor have been broken and it is no longer possible to see their arrangement.

Owing to the fact that the specimen is flattened on a slide the precise shape of the abdomen and pregenital prominence must remain uncertain; but I have made a camera lucida drawing (Fig. 89) which I hope is a little more accurate than Leigh-Sharpe's Fig. 2. Leigh-Sharpe's figures of the first and second pairs of legs are evidently not intended to show the precise setation of these limbs. All four pairs are visible in the preparation, and with the help of an immersion lens I have been able to make out the setation, which is precisely the same as that of *L. cyprinacea* (Table 1, p. 4).

Lernaea tuberosa sp. nov.

FIGS. 90–95

Holotype, Reg. No. 1949.8.14.51, and one paratype in the British Museum. Both specimens were from the body of the fish *Engraulicypris sardella* (Günther) from Lake Nyasa. The holotype was from the flank of a specimen collected by Dr. Christy in 1925, and the paratype was from the mid-ventral line of a fish in the Museum collection, Reg. No. 1908.10.27.24–33 collected by Captain Rhoades.

The length of both specimens is 11·5 mm. The positions of the five pairs of legs are 7·8, 18, 42, 72, and 91 per cent. in the holotype and 7·8, 18, 44, 76, and 93 per cent. of the body length from the anterior end in the paratype.

The total torsion in both specimens is 100° in a dextral sense. In the holotype this is the result of dextral torsions between legs 1 and 2 of 45°, between legs 2 and 3 of 40°, and between legs 3 and 4 of 15°. In the paratype the torsion is at first sinistral through 45° between legs 1 and 2, followed by dextral torsions of 105° between legs 2 and 3, 35° between legs 3 and 4, and about 5° behind legs 4.

The neck of both the specimens, that is the part of the body from the anchor to nearly the third legs, is covered with little peg-like processes which immediately distinguish this species from any other known at present, and which have suggested to me the trivial name *tuberosa*.

The anchor has four arms arranged as shown in Figs. 90 and 92–94; each bears a number of small finger-like processes. In spite of the apparent irregularity there is a distinct bilateral symmetry in the arrangement of the processes, and the two specimens are very similar to one another.

The pregenital prominence is distinct but single or only indistinctly bilobed. The abdomen is of normal length and tapering, with the segments not marked off from one another.

The egg-sacs of the holotype (Fig. 95) were small and rather shrunk in appearance.

KEY TO ADULT FEMALES

In the following key to the species of *Lernaea* those which I have seen are printed in **bold** type and those I know only from descriptions or figures are in *italics*.

The following species are omitted as I consider them to be synonyms:

L. bichiri (Kurtz, 1922)	= **L. haplocephala** (Cunnington, 1914)
L. carassii Tidd, 1933	= **L. cyprinacea** Linnaeus, 1758
L. elegans Leigh-Sharpe, 1925	= **L. cyprinacea** Linnaeus, 1758
L. pectoralis (Kellicott, 1882)	= *L. catostomi* (Krøyer, 1864)
L. temnocephala (Cunnington, 1914)	= **L. barnimiana** (Hartmann, 1865)
L. tortua (Kellicott, 1881)	= *L. catostomi* (Krøyer, 1864)
L. werneri (Kurtz, 1922)	= *L. composita* Wilson, 1924

1. Neck with many peg-like protuberances . . . . **L. tuberosa** sp. nov.
   Neck smooth 2
2. Anchor with four unbranched arms, confluent at their bases . . . 3
   Anchor with some other arrangement of its arms 12
3. A localized swelling at least twice the width of the body present in the region of legs 2 4
   Body not conspicuously swollen in region of legs 2 5
4. Abdomen of normal length, less than three times its breadth . . . **L. haplocephala** (Cunnington, 1914)
   Abdomen very long, about a quarter of the total body length **L. longa** sp. nov.
5. Arms of anchor long and straight and in a plane roughly parallel to body axis 6
   Arms not answering to this description 7
6. Pregenital prominence bilobed . . . . . . **L. tilapiae** sp. nov.
   Pregenital prominence with three lobes . *L. pomatoides* (Krøyer, 1864)
7. Anchor with dorsal arms curved and ventral arms straight **L. bagri** sp. nov.
   Anchor not answering to this description 8
8. Abdomen short, little, if any, longer than pregenital prominence . . 9
   Abdomen distinctly longer than pregenital prominence 10
9. Dorsal and ventral arms of anchor of about equal size . . . . *L. cruciata* (Lesueur, 1824)
   Ventral arms much smaller than dorsal arms . *L. tenuis* (Wilson, 1916)
10. Pregenital prominence bilobed . . . . **L. lophiara** sp. nov.
    Pregenital prominence simple 11
11. Arms not tapering, each with a kink near the end . . **L. palati** sp. nov.
    Arms thick at base and tapering rapidly . . *L. composita* Wilson, 1924
12. Anchor of four simple flattened arms, an anterior pair in front of legs 1 and a posterior pair behind these legs . . *L. variabilis* (Wilson, 1916)
    Anchor not answering to this description 13
13. Main bulk of anchor at right angles to the body like the cross-bar of a T, with the length of cross-bar at least a third of body length . . . 14
    Anchor not answering to this description 17
14. Anchor with a median dorsal process bifid at the tip . . . . *L. dolabroides* Wilson, 1918

Anchor with no median dorsal process 15

15. Lateral arms of anchor unbranched . . *L. parasiluri* Yamaguti, 1939

Lateral arms of anchor each with a dorsal branch near the end . . 16

16. Anchor with a small pair of ventral arms near middle line, body without a conspicuous constriction . . . . **L. piscinae** sp. nov.

Anchor without ventral arms. Body with conspicuous constriction between legs 3 and legs 4 . . . . . **L. diceracephala** (Cunnington, 1914)

17. Anchor with six short, rounded protuberances, three on each side, a dorsal pair, a ventral pair, and also an anterior pair at the sides of the head . **L. bistricornis** sp. nov.

Anchor not answering to this description 18

18. Anchor set at right angles to body by a ventral flexure by legs 2, arms lateral with bulbous branches. Posterior part of body much swollen . . . *L. insolens* Wilson, 1919

Not answering to this description 19

19. Anchor with a median dorsal arm which may be branched, and lateral arms . 20

Anchor with arms in pairs, no median arm 22

20. Dorsal arm twice bifid, posterior half of body behind legs 4 swollen and spindle-shaped . . . . *L. lagenula* (Heller, 1865)

Dorsal arm unbranched, or branched only once 21

21. Lateral arms simple . . . . . **L. barbicola** Leigh-Sharpe, 1930

Lateral arms branched at least once . . . *L. catostomi* (Krøyer, 1864)

22. Arms of both dorsal and ventral pairs bifid . . *L. oryzophila* Monod, 1932

Either dorsal or ventral arms unbranched 23

23. Ventral arms simple, dorsal arms branched 24

Ventral arms branched, dorsal arms unbranched 28

24. Ventral arms very short, hardly longer than breadth of head . . . **L. barnimiana** (Hartmann, 1865)

Ventral arms distinctly longer than breadth of head 25

25. Ventral arms curved outwards, with a small swelling facing anteriorly about the middle of the curve . . . . **L. barilii** sp. nov.

Ventral arms more or less straight, without a swelling 26

26. Legs 2 as well as legs 1 between the bases of ventral arms. Abdomen in line with the body . . . . . *L. ranae* Stunkard & Cable, 1931

Legs 2 situated some distance behind the bases of ventral arms. Abdomen generally at an angle with body 27

27. Arms not more than three times as long as they are broad. Dorsal arms nearly as short as ventral ones. Egg-sacs oval *L. esoscina* (Burmeister, 1835)

Arms slender and cylindrical in form. Dorsal arms distinctly longer than ventral. Egg-sacs spindle-shaped . . **L. cyprinacea** Linnaeus, 1758

28. Branches of ventral arms unequal, main branch directed outwards and smaller one directed ventrally from it. Pregenital prominence bilobed . *L. phoxinacea* (Krøyer, 1864)

Ventral arms bifid at tip with resultant prongs equal and parallel. Pregenital prominence hemispherical. . . . . *L. senegali* Zimmermann, 1923

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PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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W. J. REES

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ZOOLOGY Vol. 1 No. 2
LONDON : 1950

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Pp. 29–42; Pls. 1–2; 12 text-figures; 3 maps in the text

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is to be issued in five series, corresponding to the Departments of the Museum.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 2, of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

Issued March 1950 *Price Four shillings*

ON A GIANT SQUID, *OMMASTREPHES CAROLI* Furtado STRANDED AT LOOE, CORNWALL

By W. J. REES, D.Sc.

THE object of this note is to place on record some details of a female specimen of *Ommastrephes caroli* Furtado[1] stranded in live condition at Looe, Cornwall, in November 1940. It was acquired by the Plymouth Laboratory and was photographed before preservation by Mr. D. P. Wilson, to whom I am indebted for the excellent photographs. Subsequently it was preserved in formalin at the Laboratory, where I was able to examine it by kind permission of Mr. F. S. Russell, F.R.S.

The earliest certain record of a stranding of this species, near Scheveningen in Holland in 1661, is mentioned by Steenstrup (1887), and in the same year the species was described for the first time by Furtado from Portuguese specimens in the Lisbon Museum. It was subsequently reported from the Faroes by Lönnberg (1897), and since that date there has been a number of records—all strandings—from British waters and one from Heligoland; these are summarized by Clarke & Robson (1929) and, more recently, by Stephen (1944). Apart from these positive records, there are occasional reports of strandings unsupported by details, and probably also strandings on lonely coasts which are never reported, so that the number of actual strandings is possibly much more frequent than indicated in the literature.

It is curious that this species is known only from strandings and that all the known specimens are females. *O. caroli* most nearly resembles *O. bartrami* (Lesueur, 1821), from which it can be readily distinguished by the remarkable membranes of the third arms—this feature being absent in *O. bartrami* and *O. pteropus*. Robson (1925) described the largest example of *O. caroli* yet found from a stranding at Withernsea, Yorkshire, and although the Looe specimen is a little smaller it is larger than all the others that have been measured.

The standard measurements of *O. caroli* from Looe are given below:

Measurements in mm.

Overall length (apex to tip of right tentacle)	1,860	
Total length (i.e. including 3rd arm)	1,225	
Dorsal mantle length	670	
Ventral mantle length	650	
Maximum mantle width (excluding fins)	245	
Maximum mantle width (including fins)	570	
Width at mantle openings	205	
Length of head	170	
Interocular width	170	
Thickness of head	100	
Arm length:		
	Right	*Left*
1st	360	355
2nd	415	415
3rd	415	400
4th	445	445
Tentacle length	1,100	1,300
Tentacle, length of sucker-bearing surface	463	460

[1] I have followed Winckworth (1932) in referring this species to *Ommastrephes* although most authors have recorded the species under the name *Sthenoteuthis caroli*.

The Looe specimen agrees well with Robson's Withernsea example as regards colour and most external features and I have omitted further reference to them. I have, however, thought it desirable to redescribe the tentacles, arms, and suckers in some detail.

The first pair of arms are quadrate in section and carry 25–26 pairs of suckers in oblique pairs on ridges. The proximal six pairs are well spaced, then distally, the remaining pairs are set closer together and give the appearance of being alternate. Suckers in the first or proximal row have a diameter of less than 10 mm. Those of the second to the eleventh rows are 10 mm. or over in diameter, while those of rows 12–26 gradually decrease in size down to 1 mm. in diameter. On the right arm the largest suckers (on the fifth row) have a diameter of 13 mm. The left arm is very similar, with suckers of 14 mm. diameter in the fourth row.

Both second arms are strongly keeled along their whole length and there are twenty-seven rows of suckers beginning with medium-sized proximal ones of 9 mm. in diameter. Distally there is a gradual increase in sucker width to 20 mm. in the eighth row, followed by an abrupt reduction to 12–15 mm. in the ninth row.

The third arms have about twenty-eight pairs of suckers with similar appearance to those of the second arms. The proximal suckers are only 8 mm. in width, with a gradual increase distally to 13 mm. in the ninth row, followed by a gradual decrease. There is a well-developed keel which is much enlarged not far from the tip of the tentacle to form a strong crest. This is 70 mm. deep opposite the twenty-third and twenty-fourth rows of suckers. The lateral membrane, too, is very well developed and has a distinctive and characteristic shape—at least in the female, for the male is unknown. It extends from the base of the arm to within 60 mm. of its tip. The membrane is greatly enlarged distally to form a large, thin flap of a curious shape (Pls. 1 & 2). In the left arm this has a width of 220 mm., while in the right arm it is rather torn and is estimated to have a width in excess of 160 mm. Robson (1925) has discussed the shape of this organ in relation to the differentiation of species, but it is apparent, even in this fine specimen, that little reliance can be placed on it for taxonomic purposes because of its fragile nature.

The right and left ventral arms have thirty-six and thirty-four pairs of suckers respectively; these are widely spaced on the flat, sucker-bearing face of the tentacle. On the right arm the proximal suckers have a diameter of 7 mm., and there is a gradual increase in size to 14 mm. in the seventh row. Large suckers of 12–14 mm. diameter are maintained to the tenth pair, after which there is a gradual decrease down to 1 mm. or less at the tip of the arm. The left arm is similar, with larger suckers of 15–16 mm. diameter in the sixth to ninth rows.

The right and left tentacles respectively are 1·65 and 1·94 times the length of the dorsal mantle. The following description applies to the right tentacle. It can be conveniently differentiated into four regions to facilitate description: viz. the tip portion, the large sucker region, the locking-apparatus region, and the proximal portion devoid of suckers.

The tip portion, 87 mm. long, carries oblique rows of four suckers each at the extreme tip; these are small with a diameter of 1 mm. Proximally these become enlarged to 5–6 mm. diameter with only three in a row.

In the large sucker region of the manus there are eleven rows of suckers with four to each oblique row. The two median ones in each row are much enlarged, reaching a maximum size of 17–21 mm.; those of the first and second row adjoining the tip portion are slightly smaller with diameters of 10 and 13 mm. respectively. On each side, flanking the median suckers, are smaller, long-stalked suckers of about 8 mm. diameter. These are borne on the transverse ridges.

The locking-apparatus region (carpus) has three tubercules alternating with three smooth-ringed suckers and is similar in arrangement to that figured by Goodrich (1892) for *O. pteropus*. These smooth carpal suckers are small with a diameter of only 3 mm. The ordinary suckers of this region, counting from the most distal tubercule, are twelve in number and diminish in size down to 5 mm. proximally.

On the sucker-less part of the tentacle there are fourteen transverse ridges which become fainter and disappear towards the base.

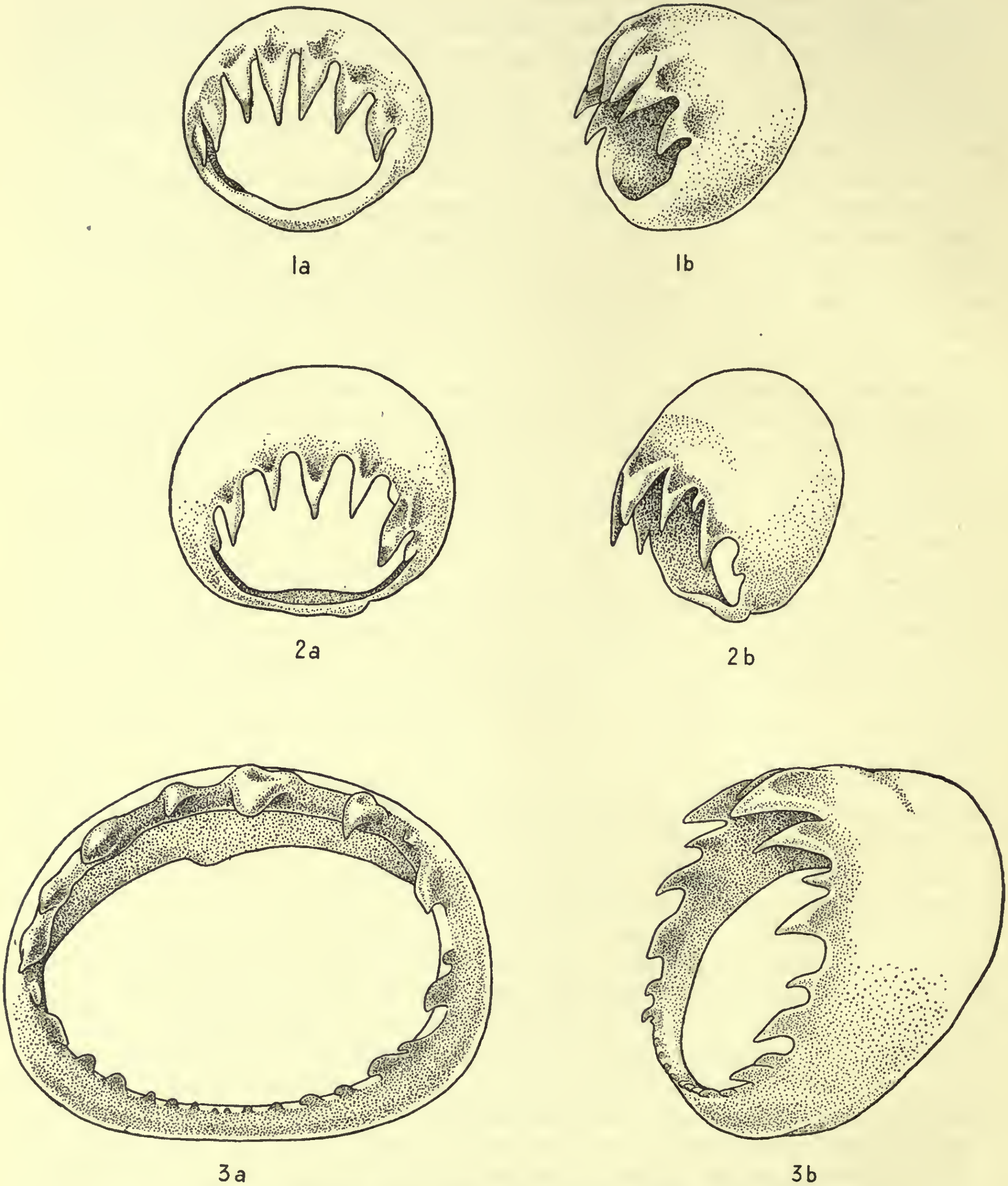
The tentacle is keeled along its dorsal surface and becomes slightly finned in the part corresponding to the distal half of the large sucker region and the proximal half of the tip portion. There are narrow, undulating fins along both sides of the sucker-bearing face. Proximally the fin on the dorsal edge is less prominent but persists as a thin ridge as far as the end of the transverse ridges. The ventral fin reaches only to the tenth transverse ridge (from the base). Sucker rings of this species have been figured by Furtado and by Lönnberg, but unfortunately those of Furtado are not very clear and Lönnberg has failed to indicate the precise position of the suckers on the arms and tentacles. As Robson (1925) has pointed out, the dentition of the rings varies according to their position, the proximal teeth of the arm suckers being lost towards the free end of the arm. The earlier figures are therefore of little use for comparison, so new ones have been drawn from known positions on the arms (Figs. 1–3).

On the basal portion of the arms the suckers are toothed all round, but the proximal teeth are small and often rudimentary (Fig. 3). Distal sucker rings have lost their proximal teeth and are of the form illustrated in Figs. 1 and 2. Typically these suckers have seven, long, backwardly directed teeth. The points where the proximal teeth disappear on each arm are fully discussed by Robson (1925).

The tentacular sucker rings are dentate all round and also show some variation according to their position (Figs. 4–6). The distal teeth are curved inwards, while the proximal teeth, although often reduced in size, are bent outwards in the same direction as the distal ones; thus the teeth of the whole ring are admirably arranged for clawing. Fig. 4 illustrates a ring with twenty-one teeth, whereas that portrayed in Fig. 5 has twenty-three teeth. The larger rings of the manus are typically ommastrephid in character with four enlarged teeth (one in each quadrant). This, the largest sucker ring of the club, has twenty-seven teeth.

The stranding of giant squids of the genera *Architeuthis* and *Ommastrephes* on British coasts has aroused much interest during the past twenty years; the significance of the strandings, especially the preponderance of records along the east coast of Britain, being the subject of speculation by Clarke & Robson (1929), Robson (1933), and Stephen (1944).

The known strandings of *O. caroli*, *O. pteropus*, and *Architeuthis* spp. are plotted on

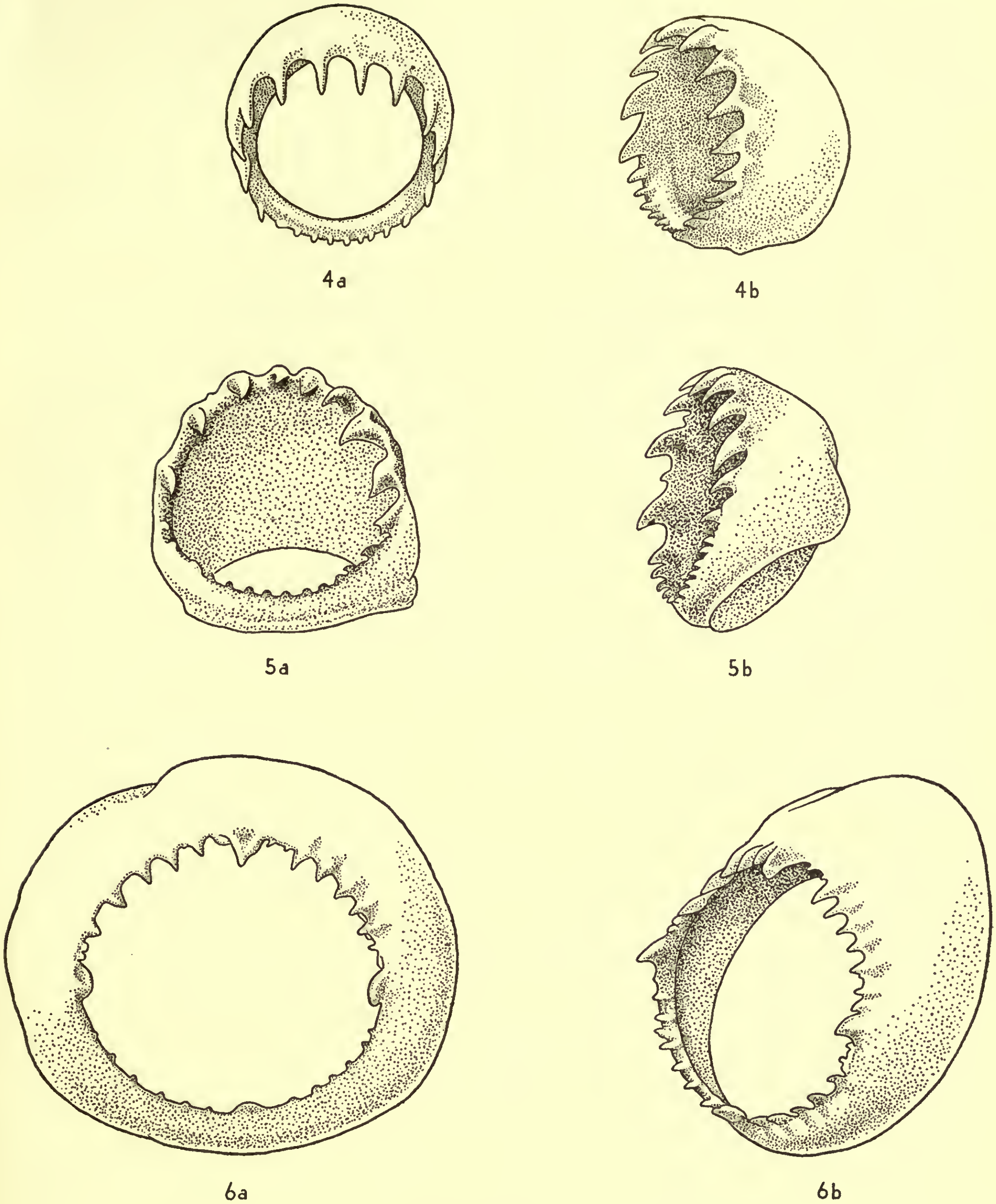


FIGS. 1–3. Sucker rings from the arms in face and oblique views.

1 *a* & *b*., ring, 3·6 mm. in diameter, from *2nd* left arm, *21st* row.

2 *a* & *b*., ring, 8·5 mm. in diameter, from *3rd* left arm, *12th* row.

3 *a* & *b*., ring, 13 mm. in diameter, from *4th* left arm, *8th* row.



FIGS. 4–6. Tentacular sucker-rings in face and oblique views.

4 *a* & *b*., medium-sized sucker-ring, 3·75 mm. in diameter, from the tip portion of the tentacle.
5 *a* & *b*., ring, 6·3 mm. diameter, from the long-stalked suckers of the manus.
6 *a* & *b*., typical ring, 18 mm. in diameter, from the middle of the manus.

Maps I–III, and it is at once evident that most of the specimens have come ashore at three places, viz. the Scarborough area, the Dunbar–North Berwick area, and at Buckie. Another feature of the strandings is that all, with the exception of a single record of *O. pteropus* at North Berwick in June 1921, have come ashore during the winter months from November to March.

Clarke & Robson correlate the strandings on the Yorkshire coast with hydrographic conditions which favour stranding, especially if the animal is enfeebled by some cause. They quote Bowman's testimony that a high percentage of drift bottles released in the north are finally stranded on the mid-Yorkshire coast and between Berwick and St. Abb's Head.

Architeuthis and *Ommastrephes* are clearly oceanic species which occasionally migrate into the North Sea, possibly during the summer months, and are later enfeebled by unfavourable conditions during the winter months. There is as yet no clue as to what these factors are, but it is probable that lack of suitable food, lower salinity (especially near the coast), and temperature fluctuations have an adverse effect.

Various Ommastrephids are, as young animals, common in the surface waters of temperate and tropical seas, but so far the habits of the large adults are a matter for speculation. Perhaps the single record of *Ommastrephes pteropus* (trawled off St. Kilda, at a depth of 180–200 fathoms in September 1925) is an indication of its normal habitat on the edge of the continental slope. Robson (1933) in discussing the distribution of *Architeuthis* was also inclined to favour this view.

If we may judge by the records plotted on Maps I–III, *O. caroli* is the most frequent immigrant into the North Sea, while *O. pteropus* is just as rare as *Architeuthis* in British waters.

The British records of these giant squids are scattered in the literature, and are, for the sake of completeness, given below.

BRITISH RECORDS OF *OMMASTREPHES CAROLI*

1. 8 Jan. 1911. Briar Dene, Northumberland; Meek & Goddard (1926). Length (including 3rd arm) 3 ft. 11 in. (1,175 mm.).
2. Feb. 1921. Isle of Skye; Stephen (1944).
3. 3 Jan. 1925. Withernsea, S. Yorkshire; Robson (1925).
4. 7 Jan. 1925. Cullercoats, Northumberland; Meek & Goddard (1926). Length (including 3rd arm) 3 ft. 8 in. (1,118 mm.).
5. 14 Jan. 1927. Buckie, Moray Firth; Stephen (1944).
6. March 1927. N. Berwick; Stephen (1944).
7. 18 March 1927. N. Bay, Scarborough, Yorkshire; Clarke & Robson (1929). Length 5 ft. 7 in.
8. 1 Feb. 1928. Scarborough; Clarke & Robson (1929). Length (including 3rd arm) 3 ft. 6 in.
9. Jan. 1929. Buckie, Moray Firth; Stephen (1944).

10–11. Dec. 1929. N. Berwick; Stephen (1944), 2 specimens.

12. 9 Jan. 1930. Filey, Yorkshire; Clarke (1930) & Stevenson (1935). Length (including 3rd arm) 3 ft. 9 in.
13. 10 Feb. 1930. Isle of Skye; Stephen (1944).
14. Feb. 1930. Isle of Mull; Stephen (1944).
15. March 1930. Dunbar; Stephen (1944).

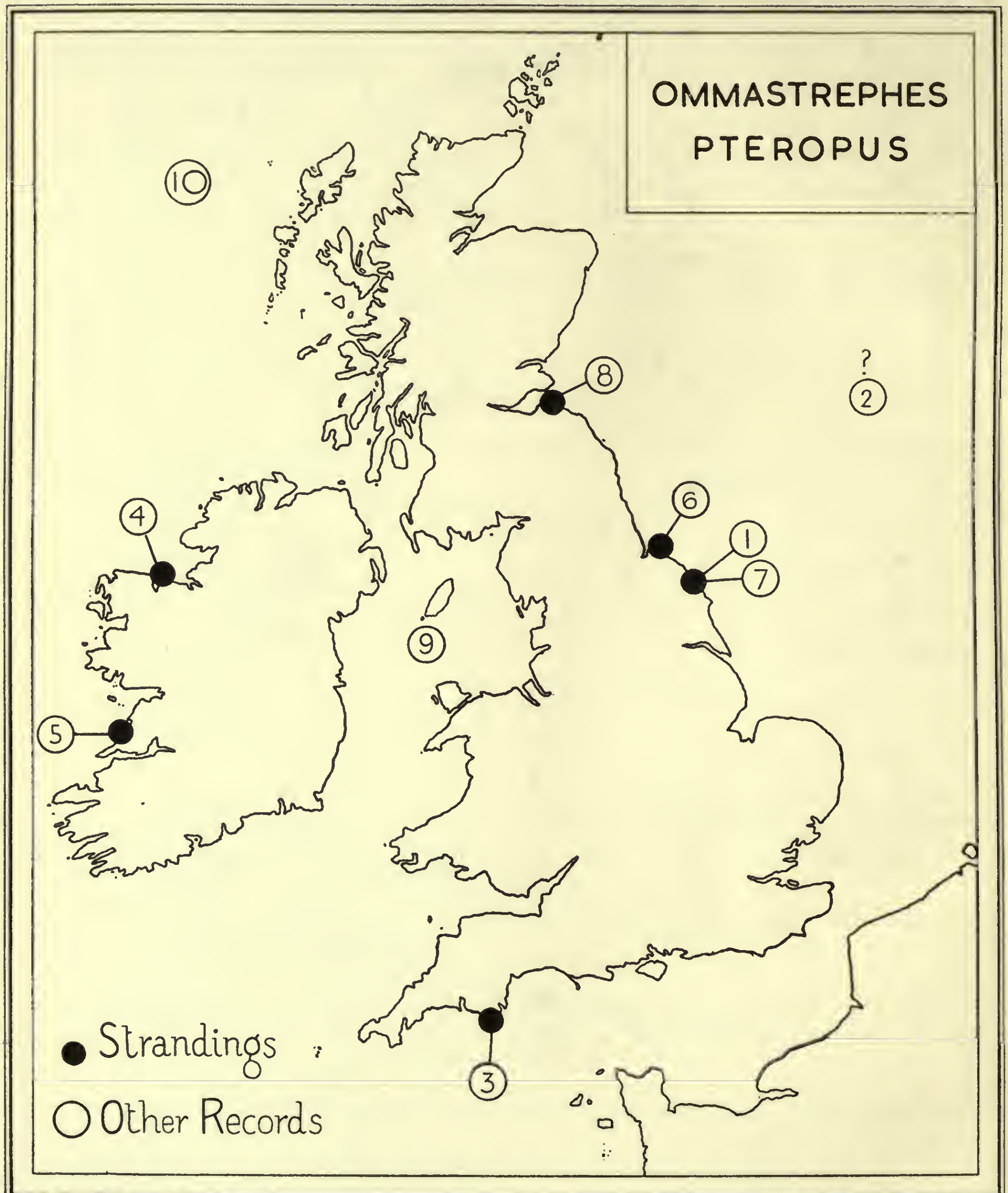
16–17. 6 Jan. 1931. Dunbar; Stephen (1944), 2 specimens.

18. 22 Dec. 1931. South Sands, Scarborough; Stevenson (1935). Overall length 5 ft. 10 in.

MAP I

STRANDINGS OF *OMMASTREPHES CAROLI* FURTADO ON BRITISH COASTS

MAP II



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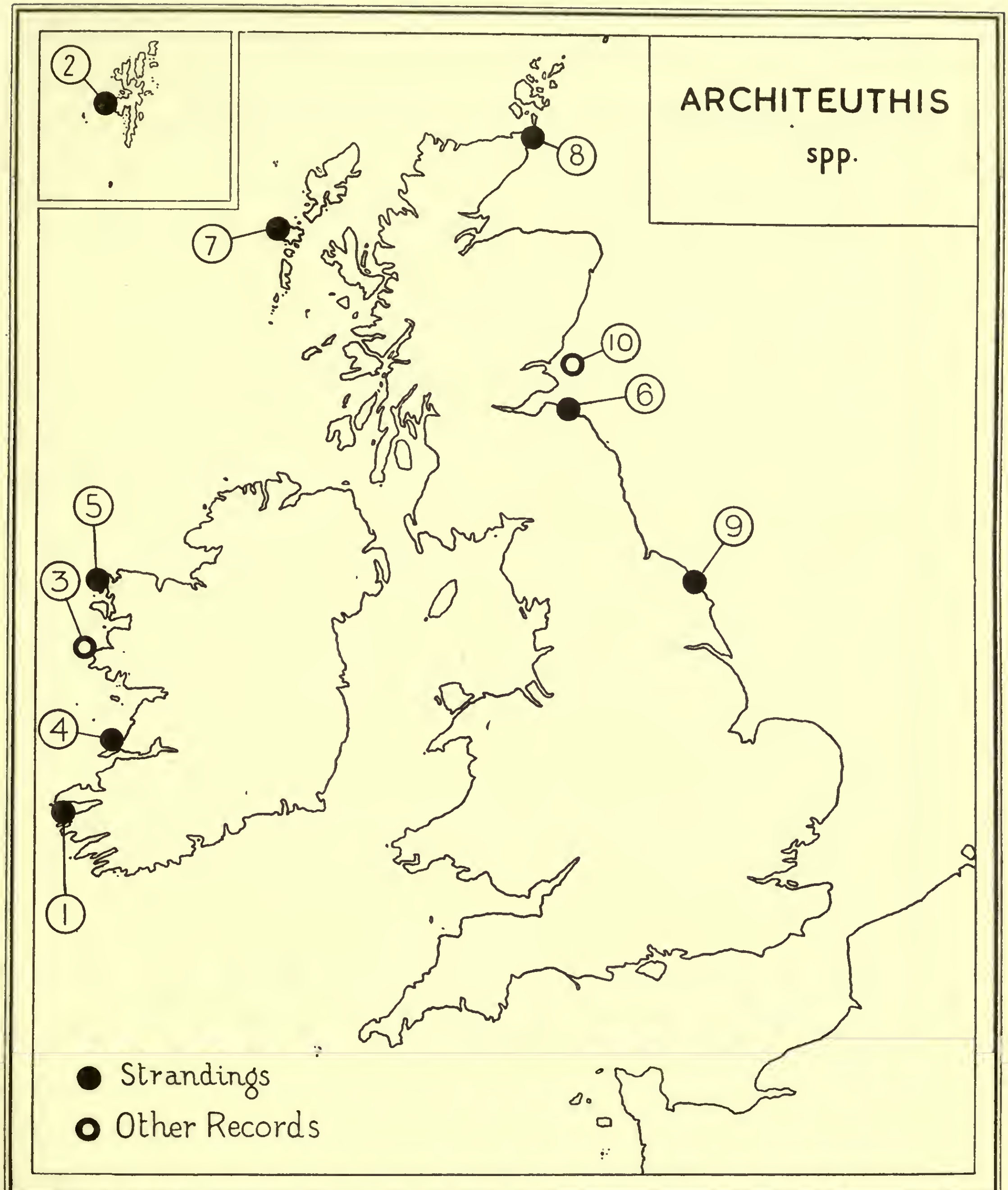
STRANDINGS AND OTHER RECORDS OF *OMMASTREPHES PTEROPUS* STEENSTRUP IN BRITISH WATERS

MAP III



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STRANDINGS AND OTHER RECORDS OF *ARCHITEUTHIS* SPP. IN BRITISH WATERS

19. 12 Dec. 1932. Buckie, Moray Firth; Stephen (1933). Overall length 6 ft. 2 in.
20. 31 Jan. 1935. South Bay, Scarborough; Clarke & Stevenson (1935). Overall length 5 ft.
21. 13 Feb. 1935. 1½ miles north of Scarborough; Clarke & Stevenson (1935). Overall length 5 ft. 2 in.
22. 3 Nov. 1935. Castlerock, Co. Londonderry; Stendall (1936). Determined by A. C. Stephen.
23. 24 Nov. 1937. Birsay Parish, Orkney; Stephen (1938). Overall length 5 ft.
24. 18 Dec. 1937. Stronsay, N. Orkney; Stephen (1938). Overall length 5 ft. 8 in.
25. Nov. 1940. Looe, Cornwall (present record).
26. Jan. 1941. Fair Isle, Shetland; Stephen (1944).

BRITISH RECORDS OF *OMMASTREPHES PTEROPUS* STEENSTRUP

1. 19 Nov. 1883. Scarborough; Goodrich (1892).
2. 27 Feb. 1884. 'North Sea'; Goodrich (1892).
3. Jan. 1892. Salcombe, Devon; Goodrich (1892).
4. ? Killala, Co. Mayo; Nichols (1905, 'many years ago').
5. ? Miltown Malbay, Co. Clare; Nichols (1905, 'a few years ago').
6. 19 Dec. 1907. Redcar; Hoyle (1908).
7. 1 Mar. 1912. Redcliff, near Scarborough. Length (including 3rd arm) 3 ft.
8. June 1921. N. Berwick, Firth of Forth; Ritchie (1922).
9. ? Isle of Man; Robson & Chadwick MS.
10. Sept. 1925. Trawled off St. Kilda in 180–200 fathoms. Overall length 6 ft. (det. Robson).

BRITISH RECORDS OF *ARCHITEUTHIS* SPP.

1. 1673. Dingle Bay, Co. Kerry, S. Ireland; (More, 1875: 4526, as *Dinoteuthis proboscideus*).
2. 1860–1861. Between Hillswick and Scalloway, W. Shetland; (Jeffreys, 1869: 124, as *Architeuthis monachus*).
3. 25 Apr. 1875. Caught at sea off Boffin Island, Connemara, Ireland; (More, 1875: 123).
4. Oct. 1880. Stranded at Kilkee, Co. Clare, S. Ireland; (Ritchie, 1918: 137, as *Architeuthis*).
5. 1914. In stomach of a sperm whale at Belmullet Whaling Station; (Hamilton, 1915: 137).
6. 2 Nov. 1917. Stranded at Dunbar, Firth of Forth; (Ritchie, 1918: 133, as *Architeuthis harveyi*).
7. Feb. 1920. Stranded at N. Uist, Outer Hebrides; (Ritchie, 1920: 57, as *Architeuthis harveyi*).
8. 1921. Stranded at Caithness, Scotland; (Ritchie, 1922: 423, as *Architeuthis harveyi*).
9. 14 Jan. 1933. Stranded at Scarborough, Yorkshire; (Robson, 1933, as *Architeuthis clarkei* n. sp.).
10. 7 Nov. 1937. Off Bell Rock, Angus, E. Scotland; (Stephen, 1937, as *Architeuthis harveyi*).

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Photo. D. P. Wilson

OMMASTREPHES CAROLI; DORSAL VIEW

Photo. D. P. Wilson

OMMASTREPHES CAROLI; VENTRAL VIEW

PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is to be issued in five series, corresponding to the Departments of the Museum.*

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This paper is Vol. 1, No. 3, of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued March 1950 *Price Three shillings*

THE IDENTITY OF CAPTAIN COOK'S KANGAROO

By T. C. S. MORRISON-SCOTT *and* F. C. SAWYER

INTRODUCTION

THE identity of the kangaroo discovered by Captain Cook's expedition in 1770 has lately been the subject of some dispute. For years this kangaroo has been referred to as *Macropus giganteus* (Zimmermann, 1777) and was thought to have been the Great Grey Kangaroo, until Iredale & Troughton (1925) not only pointed out that *giganteus* is antedated by *Mus canguru* Müller, 1776, which was based on the description and plate given in Hawkesworth's (1773) account of Cook's voyage, but also threw doubt on whether Captain Cook's kangaroo was in fact the Great Grey Kangaroo.

The ship's company of H.M.S. *Endeavour* included Sir Joseph Banks who brought with him Dr. Solander as naturalist and Sydney Parkinson as draughtsman. Iredale & Troughton (1925) published a transcript of Solander's manuscript Latin description of the kangaroos obtained by Captain Cook's party at Endeavour River (the future site of Cooktown) in June and July 1770—a description which, as Iredale & Troughton pointed out, does not accord too well with the Great Grey Kangaroo. They supported their contention that the animals in question were not Great Grey Kangaroos with the statement that the latter do not occur at or near Cooktown. Even if this were true the argument would not be valid, since the non-occurrence of the species at Cooktown nowadays does not preclude its possible occurrence there in 1770, when the country was quite undeveloped. But in fact Raven (1939) records that the Great Grey Kangaroo occurred within thirty miles of Cooktown in 1897, and Tate informs us (*in litt.*) that he obtained three specimens about fifteen miles from Cooktown in 1947.

Iredale & Troughton, though satisfied in their own minds that Captain Cook's kangaroo is not conspecific with the Great Grey Kangaroo, were unable to decide its identity but suggested that the weight of evidence pointed to a form of the *robustus* series.

The same authors (1937) next published a paper in which they sought to show that Captain Cook's kangaroo was a northern representative of the Whiptail, or Prettyface Wallaby—usually known as *Macropus* (*Protemnodon*) *parryi* Bennett, but which they hold should be called *Wallabia elegans* Lambert. This contention rests on rather insecure foundations. Briefly, the argument is that in 1929, or thereabouts, two skins were purchased in the neighbourhood of Cooktown and that Solander's description, they say, agrees with one of these which was a Whiptail—the other skin being that of a Wallaroo of the *antilopinus* type. But it is not at all clear why Cook's kangaroo must necessarily be restricted to one of the two species represented by these two purchased skins, nor is it clear why Iredale & Troughton abandoned their previous conclusions that the weight of evidence pointed to Cook's kangaroo having been a form of *robustus*.

The next stage in the controversy was a paper by Raven (1939), who holds that the evidence is decidedly against Cook's kangaroo having been a Whiptail, or Pretty-face Wallaby. With this the present writers concur. Raven further holds that the evidence supports the view that the early revisers were right in identifying Cook's kangaroo with the Great Grey Kangaroo and pleads the confusion caused by upsetting this position.

Finally Tate (1948), in the course of his review of the Macropodidae, dismissed the Whiptail theory of Iredale & Troughton and agreed with Raven that, *inter alia*, the hip stripe and face stripe of the Whiptail are too diagnostic to have been omitted from the contemporary plate and descriptions of Cook's kangaroo had the animal in fact been a Whiptail. Tate added that the only really large species of Macropodidae that conceivably could have been found near Cooktown are the Great Grey, the Red, and *Macropus robustus reginae* Schwarz, one of the antilopine group. He dismissed the second and third on grounds of colour and decided that the description and plate in Hawkesworth (1773)—and hence Captain Cook's kangaroo and *Mus canguru* Müller, 1776—agreed most closely with the Great Grey Kangaroo.

Tate avoided discussion of Solander's manuscript description, but since Solander was on board Cook's ship in his capacity as a naturalist, what he has said on the subject of the kangaroos must be examined. Here, however, we are straightway confronted with a difficulty.

Iredale & Troughton (1937) say that Solander's description was based upon the small male first captured, and Troughton (1946: 202) repeats the contention, saying that it is indisputable that it applies only to an apparently adult male weighing 38 pounds. But far from being indisputable it is not at all clear why these authors take this view at all, unless it is because the only measurements given are those of the male which Mr. Gore shot on 14 July 1770 (Solander gives the weight of this animal as 24 pounds; the difference between this and the 38 pounds of the other accounts may be the difference between the 'clean' and 'dead weight'). But Solander gives the weights of all three animals taken, and the description itself is clearly a composite one since both male and female genitalia are described and also the mammae, and Solander says that the size of the animal varies with age. Nor is it clear why Troughton refers to the 38-pound animal as apparently adult when Solander says that it was possibly two or three years old. Solander's estimate of its years may not be reliable, but he was basing his view that it was not adult on the condition of the molar teeth, as will be seen from his discussion of the latter.

But on top of this, Solander may well have had three separate species as well as three separate specimens in front of him as he wrote, and it is not possible to say which animal he had most in mind while describing the various characters. He might well have been making a qualitative average of the characters of all three. So Solander is not much help in arriving at the identity of Cook's kangaroo and any deductions drawn from his description should be treated with reserve. With this in mind it can be said that in two particulars Solander's description does not encourage any leanings towards the Great Grey theory. The rhinarium is described as 'Rostrum breviusculum, parum compressum; apice inter nares nudum ibique cute aterrima rugulosa vestitum'. But the Great Grey Kangaroo has hairy skin between the nostrils. Then again the

upper incisors are described as 'Incisores sex, approximati, lati: primum par leviter bilobum; secundum integrum; tertium latius crassiusque, bilobum: lobis anticis minoribus'. Iredale & Troughton on the one hand, and Raven on the other, perform some agile juggling with the Latin text in support of their respective theses, but what Solander says is that the third upper pair of incisors are bilobed and that the anterior lobes are the smaller, thus suiting neither the Whiptail theory nor the Great Grey theory. However, as has already been indicated, Solander's description cannot be treated as a reliable guide in the quest for Captain Cook's kangaroo.

The controversy has so far been argued in terms of Solander, Hawkesworth, and a skin obtained near Cooktown 160 years after Cook was there. It seems strange that no attempt appears to have been made to find the original specimens, especially as Iredale & Troughton (1925), quoting Hunter (1790), drew attention to the probability of a skull which Banks gave to Hunter being in the Museum of the Royal College of Surgeons. Iredale & Troughton also drew attention to the probability of a pencil drawing by Parkinson being preserved in the British Museum. But they did not pursue these two lines of research on which we now report.

DRAWINGS BY SYDNEY PARKINSON AND NATHANIEL DANCE

It seems certain that the plate of Captain Cook's kangaroo published by Hawkesworth (1773) was based on a drawing by Sydney Parkinson, the draughtsman in Banks's employ on board H.M.S. *Endeavour*. Search has been made in the British Museum (Natural History), and though the original of Hawkesworth's plate has not been found there are two rough sketches of kangaroos signed 'S. Parkinson' and marked in his hand 'Kangura Endeavour's River'. On the back of one of these Parkinson has added, 'The whole body pale ash colour the ears excepting the base fine specled gray iris of the eye Chestnut'. It was the practice of Parkinson, and other artists who accompanied Cook on his voyages, to make pencil sketches of animals seen, together with notes on the details of coloration, &c., the intention being to paint these in at a later date. In Parkinson's case, due to his death before the end of the voyage, many of the sketches were never completed. These drawings are inadequate for purposes of identification but we consider them of sufficient interest to warrant publication (Pl. 3).

Of much greater interest, however, is a wash drawing of a complete kangaroo skull and another of its lower jaw shown separately (Pl. 4). These are signed 'N. Dance' and are among the collection of Parkinson drawings which came to the British Museum from Sir Joseph Banks's library. Dryander (1748–1810), in his manuscript catalogue of the drawings of animals in Banks's library, has the following entry on page 21:

Mammalia — Glires,		KANGURU
— K	N.C.	S. Parkinson
x	Cranium	Nath. Dance

The '—' is Dryander's symbol for a pencil drawing and the 'x' for a coloured one; 'N.C.' stands for Nova Cambria, as that part of Australia was called in those days.

Sir Nathaniel Dance (1735–1811) was a celebrated portrait painter with a reputa-

tion for accuracy as a draughtsman. Captain Cook sat to him for his portrait in 1776 (*fide* Kitson, 1907), after which year Dance appears to have given up painting.

There is no indication of the scale of the drawing, but by analogy with the series of Parkinson drawings it seems likely that the skull is drawn life-size. The skull and lower jaw are both represented on a single folio sheet. Parkinson's drawings are also on folio sheets and his practice was to draw objects life-size except where they were too big for the paper. In this case he reduced them, but he did not make drawings larger than life-size. This seems to have been the general practice of the time. The point is not pressed, but if Dance's drawing is life-size, then it is likely to be that of the skull of the 84-pound kangaroo shot[1] on 27 July 1770; the other two beasts, one shot by Lieutenant Gore on 14 July and another caught by Banks's greyhound on 29 July, were smaller.

The skull drawn by Dance appears to be that of a young *Macropus robustus*. We have been unable to trace the skull itself.

ANOTHER OF CAPTAIN COOK'S SPECIMENS

John Hunter, in his observations on animals in White's *Journal* (1790), says: 'Of the Kangaroo . . . the only parts at first brought home were some skins and sculls; and I was favoured with one of the sculls from Sir Joseph Banks.' The posthumous papers of Hunter (1728–93) edited by Owen (1861) contain the same words, but Owen has added a footnote to the last sentence quoted above, which reads: 'No. 1732 Hunt. Osteol.'

Professor Wood-Jones has searched for this skull in the Museum of the Royal College of Surgeons but it cannot be found, and appears to have been destroyed by bombs along with many other Hunterian specimens during the 1939–45 War. However, he drew our attention to a figure of a skull in a paper on the history of surgery by Webb-Johnson (1939). The text to this figure says: 'Kangaroo's skull, from the Hunterian collection brought from Australia ("New Holland") by Sir Joseph Banks when with Captain Cook's Expedition, 1768–71.' The figure itself is a reproduction of a photograph and it shows quite clearly the number '3703' painted on the skull. Flower's catalogue (1884) makes it plain that No. 3703 is the same specimen as No. 1732 in Owen's catalogue (1853). Webb-Johnson's figure is small and not very clear, but Professor Wood-Jones went to much trouble and eventually found a lantern slide of the same photograph. This slide (Pl. 5) is probably one Webb-Johnson had made when he read his paper in 1939. The skull it represents is clearly not the same as the one drawn by Dance and it appears to be slightly younger, an impression which is borne out by the description of its dentition in Owen's catalogue (1853). The skull is from one of the three animals obtained at Endeavour River in 1770 and is probably that of the 38-pound animal shot by Lieutenant Gore on 14 July 1770.

As will be seen from Plate 5, the skull is a young one and the incisors are missing. In view of its important bearing on the nomenclature of the genus *Macropus*, we sent the photograph to Dr. G. H. H. Tate, who has recently (1948) monographed the

[1] By Lieutenant Gore, according to the journal of Midshipman John Bootie, who records the weight as 80 pounds.

kangaroos, and himself collected specimens in the neighbourhood of Cooktown. We are indebted to him for his detailed report on this skull which he unhesitatingly refers to the Great Grey Kangaroo—amongst other characters the short ante-orbital canal and the 'zog' in the maxillo-premaxillary suture being particularly characteristic.

CONCLUSION

Captain Cook's first expedition to Australia obtained three specimens of kangaroo, all from Endeavour River, Queensland, July 1770. The skull of one of these was still preserved in the Museum of the Royal College of Surgeons in 1939 but was destroyed by bombs during the late war. No trace of the other material has been found.

The only figure of the original material hitherto generally known to zoologists is the plate in Hawkesworth (1773) of a not easily determinable kangaroo, or reproductions of it. Four more figures are now published. The first two are indeterminable outline drawings of the whole animal by Parkinson, who was on board Cook's ship. The third is a painting of a skull by Nathaniel Dance. This is almost certainly the skull of one of Cook's specimens; in fact it is difficult to see where else it could have come from. It is the skull of a Wallaroo of the *Macropus robustus* series.

The fourth is a photograph (Pl. 5) of the specimen which was destroyed in the Museum of the Royal College of Surgeons. This skull was from one of the kangaroos obtained by Cook's party at Endeavour River in July 1770. It was given by Banks to Hunter and is No. 1732 in Owen's catalogue (1853) and No. 3703 in Flower's catalogue (1884). It is the skull of a young Great Grey Kangaroo and we hereby designate it as the photo-lectotype of *Macropus canguru* (Müller, 1776)—'Captain Cook's Kangaroo'.

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PLATE 3

FIGS. 1 AND 2. Pencil sketches by Sydney Parkinson of kangaroos seen at Endeavour River, Queensland, in July 1770. (Preserved in the Zoological Library of the British Museum (Natural History))

FIG. 1

FIG. 2

PLATE 4

Fig. 3. Wash drawing by Nathaniel Dance of the skull of a young kangaroo (*Macropus robustus* subsp.) obtained at Endeavour River, Queensland, in July 1770

Fig. 4. Lower jaw of the skull in Fig. 3


ETRES 2 3 4 5 6 7 8 9 10 11 12 13 14

FIG. 3

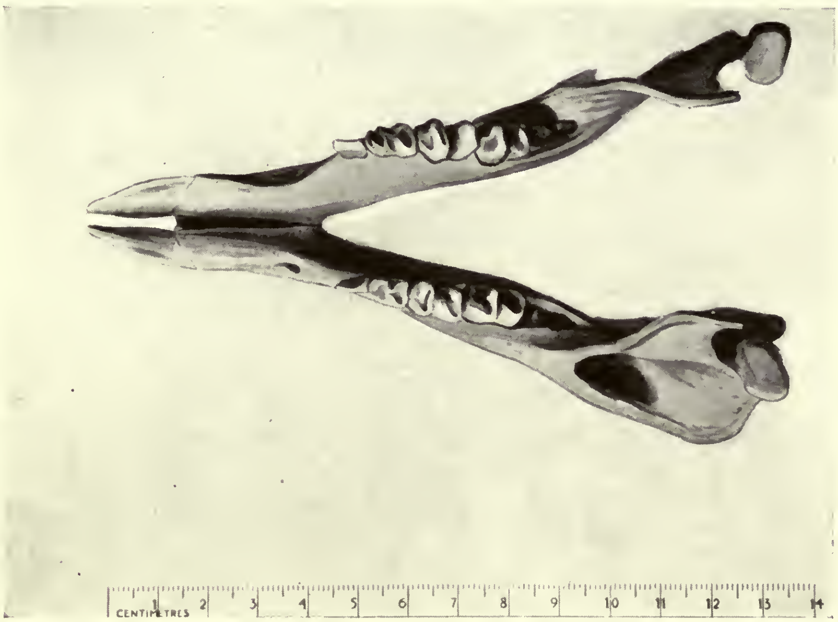
CENTIMETRES 1 2 3 4 5 6 7 8 9 10 11 12 13 14

FIG. 4

PLATE 5

FIG. 5. Photograph of the skull of a young Great Grey Kangaroo obtained at Endeavour River, Queensland, by Captain Cook's party in July 1770. This plate is the photo-lectotype of *Macropus canguru* (Müller). The specimen, which no longer exists, was number 1732 in Owen's Catalogue (1853) and number 3703 in Flower's Catalogue (1884). Scale unknown

FIG. 5

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NOTES ON ASTEROIDS IN THE BRITISH MUSEUM (NATURAL HISTORY)

D. DILWYN JOHN

LERNAEODISCUS PUSILLUS NOV. SPEC. A RHIZOCEPHALAN PARASITE OF A *PORCELLANA* FROM EGYPT

H. BOSCHMA

BULLETIN OF
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ZOOLOGY Vol. 1 No. 4
LONDON : 1950

NOTES ON ASTEROIDS IN THE BRITISH MUSEUM (NATURAL HISTORY) (2)

BY

D. DILWYN JOHN

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BY

DR. HILBRAND BOSCHMA

Pp. 51–65; *Pl.* 6; 4 *Text-figures*

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in* 1949, *is to be issued in five series, corresponding to the Departments of the Museum.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

These papers form Vol. I, No. 4, *of the Zoological series.*

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued August 1950 *Price Four Shillings*

NOTES ON ASTEROIDS IN THE BRITISH MUSEUM (NATURAL HISTORY)

2. SOME ASTROPECTINID SPECIES

By D. DILWYN JOHN

(DIRECTOR OF THE NATIONAL MUSEUM OF WALES, CARDIFF)

(*With Plate* 6)

The first Note in this series (John, 1948) began with the statement that the Asteroids in the British Museum (Natural History) were being revised. This, the second Note, will be the last in the series by the present author, who has since left the Museum staff. It is shorter than it was intended to be and deals only with the following six Astropectinid species:

Lonchotaster tartareus Sladen.
Dytaster exilis Sladen.
Plutonaster agassizii (Verrill).
Leptychaster antarcticus Sladen.
Leptychaster kerguelensis Smith.
Craspidaster hesperus (Müller & Troschel).

Lonchotaster tartareus Sladen

Lonchotaster tartareus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 104, pl. 16, figs. 1–5.

The only species and the only specimens of the genus *Lonchotaster* remain those described by Sladen in 1889, *L. tartareus* from 2,400 fathoms between the Canaries and the Cape Verde Islands, and *L. forcipifer* from nearly 2,000 fathoms in the Southern and Antarctic Oceans south-west of Australia. The large Astropectinid described by H. L. Clark (1916: 30) as *Lonchotaster magnificus* was referred to *Dipsacaster* by Fisher (1919: 150).

Fisher, both in 1917 (p. 170) and 1919 (p. 150), makes what are, in effect, minor corrections to Sladen's account of *L. tartareus*, saying there is a small spine on each marginal plate and one on most of the actinal intermediate plates; he refers to Sladen's figures as bearing out his statement. As for the superomarginal plates, Fisher is wrong and Sladen's account, with which his plate agrees, is correct: 'within the interbrachial arc and at the base of the rays in the large example, a small conical tubercle is present close to the upper end of the plate, but it is not found in the smaller specimens'. For the inferomarginals neither Sladen's account nor Fisher's is quite correct. In the larger specimens there are small spines, of diminishing size, as far out as about the thirtieth plate, but not beyond; they are present on the plates of the interbrachial arc of one of the smaller, entirely absent from the other.

Sladen's account of the spination of the actinal intermediate plates is correct, including the implication that there are no spines on those of the smaller specimens.

Dytaster exilis Sladen

Dytaster exilis Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30** : 65, pl. 2, figs. 3 & 4 ; pl. 4, figs. 9 & 10 (figs. of var. *gracilis*) ; Wood-Mason & Alcock, 1891 : 429 ; Alcock, 1893 : 80.

The *Challenger* took the type of *D. exilis* off Valparaiso in the Pacific, those of its varieties *gracilis* and *carinata* in the Atlantic near Tristan da Cunha and off the Maryland coast of N. America respectively. The only subsequent records are those of *exilis* itself by Wood-Mason and Alcock from the Bay of Bengal, where it 'has several times been met with . . . between 1748 and 1924 fathoms on globigerina ooze'. They did not describe their specimens beyond giving the colour when fresh as salmon-pink.

One of their specimens, from St. 117, 1,748 fms., is in the British Museum. It is dry and small: $R = 47$ mm., $r = 9$ mm., $R : r$ is 5·2. The abactinal paxillae have four to ten finely thorny spinelets; there are no pedicellariae among them. The superomarginals number thirty-three. They are not confined to the lateral wall but encroach a little on the abactinal surface; those in the inter-brachial angle do so to the extent of 1 mm. This is a marked difference to the type of *exilis*; in the variety *gracilis*, on the other hand, they do encroach abactinally though not so strongly as in this specimen. When seen from the side the length of the plates is less than the height in the inter-brachial angle, greater than it in mid-arm, equal to it at the end of the arm. The large spines are missing from the plates at the ends of the arms which are abraded, but I am unable to say if they have merely been rubbed off.

The inferomarginals correspond to and are of the same size as the superomarginals as seen from the side. On the actinal surface their breadth is greater than their length on the inner part of the ray. In the interbrachial angle some of the marginal plates of both series carry two spines.

The enlarged spine on the adambulacral plate first appears about half-way down the arm and arises more often from the second than the first comb of spines. The latter has ten, the former eight, spines, and they are followed by a third row as Sladen describes for *exilis*. The actinal intermediate plates extend to about the third inferomarginal. Each bears a group of widely spaced spines, up to fourteen on the largest. They and the spines of the marginal and adambulacral plates are finely thorny.

The madreporite is neither large nor conspicuous.

In the shape of the superomarginal plates, the absence of pedicellariae, and the occurrence of the enlarged spine on the adambulacral plates I see this specimen as nearer to the var. *gracilis* than to *exilis* itself. Experience with other species leads me to believe it possible that more specimens may serve to bridge the gap which now appears to exist.

Verrill (1895 : 131) was not able to satisfy himself that *D. exilis* var. *carinata* was distinct from the young of his *D. grandis* (of which *D. madreporifer* Sladen is a synonym). A direct comparison leaves no doubt of its distinctness. In the first place the larger specimen described by Sladen cannot be regarded as young, having $R =$ 98 mm. The paxillae of its disk are comparatively large, those of *grandis* conspicuously small; the pedicellariae on the actinal intermediate plates of *carinata* are larger and

of valves more highly modified than those of *grandis* (Plate 6, fig. 1); the adambulacral armature differs, for whereas *grandis* has only one row of strong furrow spines, *carinata* has two, the second being of the peculiar dagger-like form described by Sladen. Finally, the appearance of the two forms is quite different to the naked eye for, whereas *D. grandis* is distinguished by the strong high sides which the marginals give to its rays, in the var. *carinata* the marginals are comparatively poorly developed, their combined height being only a little more than half that of *grandis*, and the spines are correspondingly smaller (Plate 6, figs. 2 & 3).

Plutonaster agassizii (Verrill)

Archaster agassizii Verrill, 1880, *Amer. J. Sci.* **20**: 403.

Plutonaster rigidus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 91, pl. 14, figs. 3 & 4; pl. 15, figs. 3 & 4; Koehler, 1909: 19, pl. 4, fig. 6; pl. 10, figs. 5 & 6.

Plutonaster rigidus var. *semiarmata* Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 94, pl. 14, fig. 5.

Plutonaster agassizii Verrill, 1894, *Proc. U.S. Nat. Mus.* **17**: 248; 1895: 131; 1899: 211, pl. 27, fig. 6.

Verrill (1880: 403) in his 'Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England' described the new species *Archaster agassizii*. Sladen (1889) made no reference to Verrill's paper in the *Challenger* Report. In 1894 (p. 248) Verrill placed his species in Sladen's genus *Plutonaster*; listed Sladen's *rigidus* and *rigidus* var. *semiarmata* and a part of his *bifrons*, all from off the coast of North America, as synonyms; and added to the description. In 1899 he described the species as occasionally having pedicellariae and gave a figure showing one.

Koehler (1909: 19) used Sladen's name, *rigidus*, for describing a series taken in mid-Atlantic in the latitude of the Azores, explaining that he did so because he could not be sure that Verrill's *agassizii* and Sladen's *rigidus* were the same. He found Verrill's description inadequate and his attempt to have photographs of his specimens compared with Verrill's had failed.

Dr. Austin Hobart Clark has generously made it possible for me to make the sort of comparison that Koehler wished to make by sending me six specimens of Verrill's species. They came from off New Jersey, 39° 58′ 30″ N., 70° 30′ 00″ W., 384 fms.

They show that *agassizii* and *rigidus* are one. Koehler had found that the var. *semiarmata* of Sladen could not be maintained, so variable is the occurrence of spines on the inferomarginal plates. Verrill (1894: 248) says that there may be all gradations from those having no marginal spines whatever to those that have a large spine on nearly every marginal plate of both series. Koehler does not record spines on the superomarginal plates and it may be assumed that they were not present in his specimens. There is none in the six specimens from Verrill before me, but in the type of Sladen's *rigidus* there is on one or two plates a single slightly enlarged granule such as I have seen to occupy a similar position from which a spine often arises in other asteroids.

Koehler makes no mention of pedicellariae. I find a row of four to be present actinally in the midline of one interradius of one of Verrill's specimens, and a single

one in another interradius. They have four or five blades. The type of *rigidus* has some small groups of spines in the actinal intermediate areas which are pedicellaria-like in their disposition, but the 'blades' are short and coarse.

Sladen (p. 92) described the conical spinelet immediately behind the furrow spines on the outer adambulacral plates. Though Koehler did not mention it, it is to be assumed it was present since he identified his specimens with Sladen's species. It is present in Verrill's specimens, more strongly developed in some than in others.

$R:r$ is more than 3 in one of Verrill's specimens ($R = 49$ mm., $r = 15$ mm.); it is less than 3 in the remaining five in which R varies from 42 to 63 mm. and r from 17 to 22 mm.

Verrill included the small specimen which Sladen (p. 88) described with a query as *P. bifrons* in his synonymy of *agassizii*. It possesses a spine on each marginal plate, inferior and superior; there is a large spine behind the furrow series on each adambulacral plate. In view of its origin it is probably the young of *agassizii*, but it cannot be said with certainty that it is.[1]

Leptychaster antarcticus Sladen and ***L. kerguelensis*** Smith

Leptychaster antarcticus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30** : 190, pl. 31, figs. 3 & 4; pl. 32, figs. 7 & 8.
Leptychaster kerguelensis Smith, 1876, *Ann. Mag. Nat. Hist.* **17** : 110.

The type of *L. antarcticus*, and a second and smaller specimen taken with it ($R = 10{\cdot}5$ mm., $r = 4{\cdot}5$ mm.), are in the Museum collection. They are the only specimens recorded. Bell (1908: 9) thought them the young of *kerguelensis*, but he gave no good reasons for doing so.

Koehler (1917: 53) discussed the question and Fisher (1940: 83) referred to it, but, while not affirming that Bell was wrong, neither accepted his conclusion. It seemed well that I, with access to the types of both species, should re-examine them and other available specimens and report what I find.

The paxillae of the greater part of the swollen abactinal surface of the type of *antarcticus* have lost their spines. It may have happened during transport to and from a safe place in the Second World War. They appear to have been present when the *Challenger* figure (pl. 31, fig. 3) was made. While Sladen's written description is of his usual excellence, fig. 4, pl. 31, is a poor representation: it is, indeed, a misrepresentation of the mouth plates, which are as Sladen describes them in words. It is hoped that the photograph given here conveys a better idea (Plate 6, fig. 4).

Sladen's description of *kerguelensis* is of a large specimen of $R = 66$ mm.; though he listed smaller specimens and gave their sizes he did not otherwise describe them. He states (p. 192) that *kerguelensis* is distinguished from *antarcticus* by the longer and more cylindrically rounded rays, by the larger and more compact paxillae, by the smaller actinal intermediate areas, and, above all, by the characteristic adambulacral armature.

The smallest specimen of *kerguelensis* in the collection was taken with three larger

[1] A doubt is possible about its origin. On p. 87 Sladen gives it as St. 47, off the coast of N. America. On p. 88 he gives St. 47*a*. There was no *Challenger* station of that number but there was one by the *Porcupine* and it was in the Faroe Channel.

specimens (R up to 60 mm.) in 50 fms., off Marion Is. In it $R = 13{\cdot}8$ mm. and $r = 5$ mm., so that it is slightly smaller than the type of *antarcticus* ($R = 15$ mm., $r = 6$ mm.). A direct comparison has been made between them. The rays of the *kerguelensis* specimen are, in proportion, longer and more rounded, and the actinal intermediate areas are smaller; and the differences in proportion give a different facies to each specimen.

But the paxillae are similar in the two specimens and as Sladen described them for *antarcticus*, though his figure is not very good. It is, however, far better than is that of the paxillae of *kerguelensis* (pl. 32, fig. 1). In only three of the fifteen Museum specimens are they as shown in that figure, with the spines represented by low rounded granules, tending to be polygonal where crowded. In the others they are much more spine-like and radiate apart. Though it is not necessarily the biggest specimens in which the paxillae spines are lowest and most crowded, it is in the smallest that they are most spine-like. In short, the distinction between *kerguelensis* and *antarcticus* based upon the nature of their paxillae appears not to be real.

The question of the adambulacral armature remains. It can only be said that Sladen's descriptions are correct and that his figs. 2 & 8, pl. 32, are good representations. It may be added that Koehler's eight specimens of *kerguelensis* conformed with Sladen's description for that species, and that it is implicit in Fisher's account that his three specimens also did so.

And so, since no intermediate stages have been found, it seems best to go on regarding *kerguelensis* and *antarcticus* as distinct species distinguished by their different adambulacral armature.

The three starfishes from the Cape which Bell (1905: 242) recorded as *L. kerguelensis* are *Dipsacaster sladeni* Alcock, as Mortensen (1933: 237) pointed out. Bell (1908: 9) also recorded the species from the Ross Sea, including one specimen in which $R =$ 212 mm. I cannot find that specimen; nor are there any Ross Sea specimens labelled *L. kerguelensis*. There are several jars labelled by Bell '*Leptychaster* young' or 'very young', and I suppose them to be the young examples to which he referred. They are, however, not *Leptychaster* but *Odontaster*—and some other genera are included.

Craspidaster hesperus (Müller & Troschel)

Archaster hesperus Müller & Troschel, 1840, *Ber. preuss. akad. Wiss.*: 104.
Craspidaster hesperus Sladen, 1889, *Rep. Voyage Challenger* (*Zool.*), **30**: 177, pl. 17, figs. 5–7; pl. 18, figs. 1–4; Döderlein, 1921: 5 (for synonymy), 8, pl. 1, figs. 2–3.
Craspidaster glauconotus Bedford, 1900, *Proc. Zool. Soc. Lond.*: 290, pl. 24, figs. 8*a*, *b*; Döderlein, 1921: 8, pl. 1, figs. 4–6.
Craspidaster hesperus crassus Döderlein, 1921, *Siboga Exped.* Monog. **46 i**: 9, pl. 1, figs. 1 & 1*a*.

There are in the British Museum thirty-nine specimens. One is from an unknown locality, five are said to be from Japan but there can be no certainty of it, twenty-one from the Chusan Archipelago, one from Amoy, and another from Hong Kong (*Challenger*), two each from the Philippines (*Challenger*) and Batavia, and six specimens of Bedford's *glauconotus* from Malacca.

Döderlein had twelve specimens and took into account, for measurements, &c., three more. He recognized three sub-species differing from one another in the length

and width of the arm, the number, size, and spination of the marginal plates, and the number and nature of the actinal intermediate plates. Four of his specimens were from China and Japan, the remainder from East Indian or Malayan seas. The former had shorter and wider arms, and larger and—on the whole, and especially in the second row—fewer actinal intermediate plates. One of the Chinese specimens of unusually plump form, with massive marginals and having only one row of actinal intermediate plates, he made the type of a new sub-species, *crassus*; the remainder he regarded as typical *hesperus*. The Malayan examples, with longer more slender arms, more numerous marginals, smaller and more actinal intermediate plates—especially in the second row—and with, in the larger, spines on the ventral faces of the inferomarginals, he grouped with Bedford's specimens in the sub-species *glauconotus*.

The present collection bears out Döderlein's conclusions concerning the relation of $R : r$, and the number of marginal plates. In the twenty-one Chusan specimens R ranges from 8·5 to 42 mm. and the relation $R : r$ varies from 2·1 in the smaller to 3·5 in the larger. In the six specimens of *glauconotus* from Malacca the range of R is 18 to 67 mm. and of $R : r$ 3·2 to 4·6. There is no doubt that the latter are conspicuously longer-armed. They have, too, a larger number of superomarginal plates. Perhaps the most telling way of making a difficult comparison is to bring together (1) a number of specimens of roughly equal sizes, as follows:

Locality	*R in mm.*	*R : r*	*No. of marginals*
? Japan	34	3·2	24
Chusan	29·5	3·1	23
Timor (Döderlein)	29	3·6	26
Malacca (*glauconotus*)	31	4·4	33

and (2) a number of specimens with roughly equal numbers of marginal plates:

Locality	*No. of marginals*	*R*	*R : r*
? Japan	27	41	3·4
Chusan	30	42	3·5
Hong Kong	31	53	3·6
Philippines	31	37·5	3·8
Malacca (*glauconotus*)	33	31	4·4

The first list shows that Bedford's *glauconotus* is sharply marked off from the other specimens by the high value of $R : r$ and by the large number of marginal plates; the second, that a specimen of *glauconotus* with a given number of marginals is of much smaller major radius and has a markedly higher value of $R : r$ than specimens of *hesperus* with the same number of marginals.[1] Each list tells the same story, but by means of different specimens.

One of the Batavia specimens is roughly equal in size ($R = 57$ mm.) to one of those from Malacca ($R = 59$ mm.). $R : r$ is 4 in the former, 4·3 in the latter, and the relative numbers of marginal plates are 40 and 47.

[1] The large major radius of the Hong Kong (*Challenger*) specimen is because of its peculiarly massive marginals; compare the type of *crassus* which, with only 20–22 marginals, has $R = 46$ mm.

The spines on the lower surfaces of the inferomarginal plates and on the actinal intermediate plates afford a strong difference between Bedford's *glauconotus* and typical *hesperus*. They are well developed on each of the six specimens. They occur, strongly on the inferomarginal plates, poorly developed on the actinal intermediate plates, of the larger specimen ($R = 57$ mm.) from Batavia; there are traces of them on the actinal-intermediate plates only of the second Batavian specimen ($R = 57$ mm.). There are spines, varying in number but never numerous, on the lower surfaces of the inferomarginals of (1) the *Challenger* specimen from Hong Kong (an odd one or two), (2) the larger *Challenger* specimen from the Philippines (one on each of two rays), and (3) one of the Japan specimens (one on each of the first eight plates).

I find nothing to support Döderlein's implication that there is a real difference in the number of actinal intermediate plates of 'Chinese' and 'Malayan' specimens. He gives as a characteristic of some of the former that they have few and massive plates, sometimes only one row (var. *crassus*). It is true that in the British Museum collection six of the smaller specimens from Chusan ($R = 10$–17 mm.) have only one row, but since the remaining and larger specimens have two rows, and the largest specimens have the highest number of plates, this is clearly a matter of growth. The only other specimens with no second row of actinal intermediate plates are (1) one of *glauconotus* of no less than $R = 60$ mm. (no second row in two interradii; a single plate comprises the 'second row' in each of the other three); (2) the smallest specimen of *glauconotus* ($R = 18$ mm.); (3) Sladen's 'young phase' ($R = 22$ mm.) from the Philippine Islands. The largest *glauconotus* ($R = 67$ mm.) has six to eight plates in the first, three plates in the second, row. The specimen from an unknown locality is exceptional: it has $R =$ only 31 mm. and yet has seven to eight plates in the first row, three to four in the second, and it possesses a third row of one plate on either side.

Sladen described the occurrence of a thumb-like spine on the aboral margin of the adambulacral plates of his Hong Kong specimen and its absence from those from the Philippines. It was not present in the specimens from the Philippines seen by Fisher (1919: 60). Döderlein does not mention it.[1] It is (as Bedford says) present in *glauconotus*; I find it in each specimen from the smallest ($R = 18$ mm.) to the largest ($R = 67$ mm.). It is present in the specimen from an unknown locality and in that from Amoy, in three of those from Japan ($R = 35$–41 mm.), but it is absent from all but a few plates of the fourth ($R = 34$ mm.). It is not present in the two specimens from Batavia. It is absent from twenty of the twenty-one specimens from Chusan of $R = 8{\cdot}5$ to $29{\cdot}5$ mm., but is present in the twenty-first which is conspicuously larger having $R = 42$ mm.

The conclusion appears to be that in the present state of our knowledge *glauconotus* should continue to rank as a sub-species distinguished by the length of its rays, the number of its marginals, and the presence of spines on the inferomarginal and actinal intermediate plates; but that *crassus* cannot be maintained. The species is seen to be variable: e.g. the Hong Kong specimen approaches Döderlein's *crassus* in its massive marginals and yet bears traces of spines, a *glauconotus* character, on some of them; the thumb-like spine of the adambulacral plate is absent from most small

[1] His fig. 6*a* on pl. 1 shows it to have been absent from his specimen from Lombok. Text-fig. 1 and the accompanying text do not make clear the possibility of its existence.

specimens but it is present in one *glauconotus*, $R = 18$ mm., and it may be entirely wanting on large specimens up to $R = 57$ mm.

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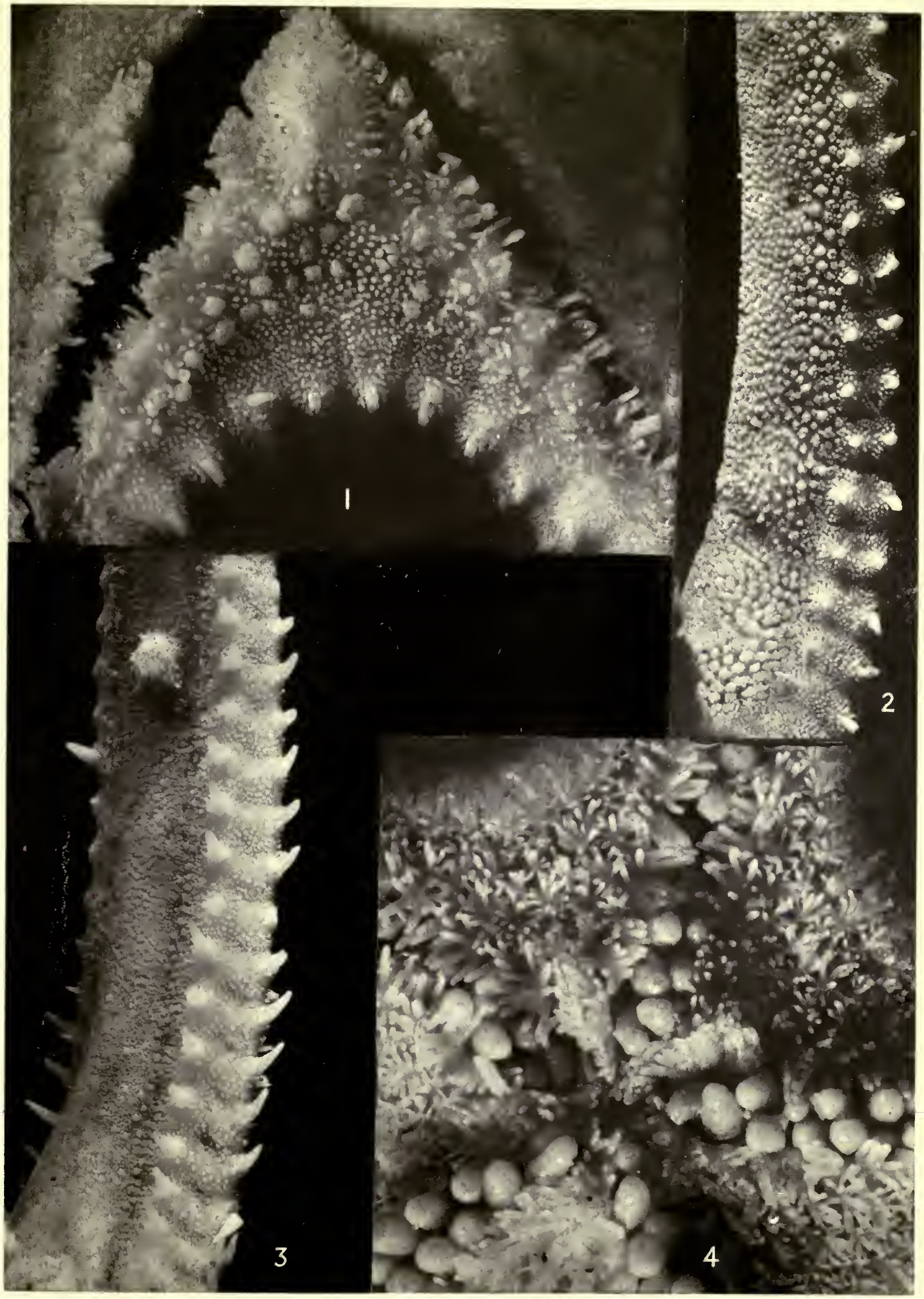
PLATE 6

FIG. 1. *Dytaster exilis* var. *carinata*, type, mouth-angle and actinal-intermediate area, × 5.

FIG. 2. *Dytaster exilis* var. *carinata*, type, side view of the proximal portion of arm, × 4.

FIG. 3. *Dytaster grandis*, cotype, side view of proximal portion of arm, × 4.

FIG. 4. *Leptychaster antarcticus*, type, under surface of disk, × 10.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LERNAEODISCUS PUSILLUS NOV. SPEC., A RHIZOCEPHALAN PARASITE OF A *PORCELLANA* FROM EGYPT

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IN 1936 Dr. Isabella Gordon kindly sent me twelve specimens of Rhizocephalan parasites on Porcelain Crabs collected by Dr. R. Gurney in coral rock on the Harbour Reef near Ghardaqa, Red Sea, Egypt. The hosts of these parasites were provisionally identified as *Porcellana serratifrons* of Nobile, *nec* Stimpson. The parasites appear to represent a hitherto undescribed species.

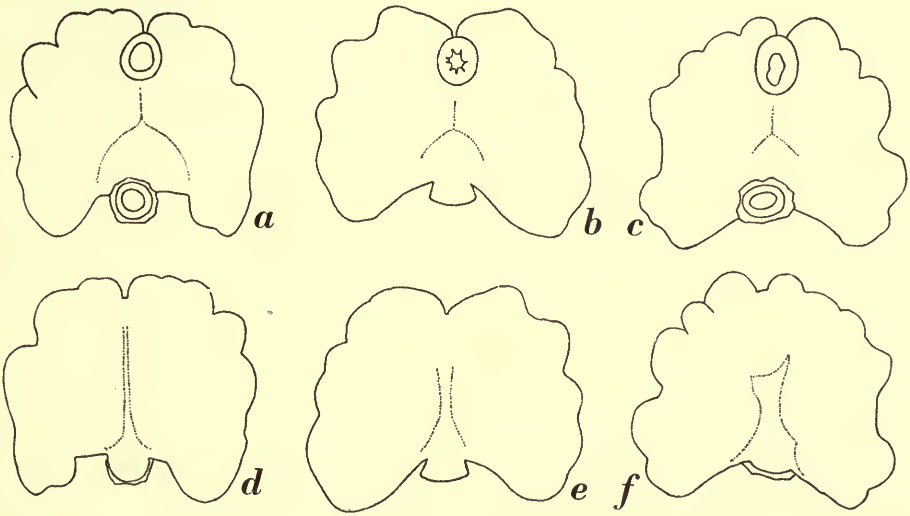

FIG. 1. *Lernaeodiscus pusillus*: *a–c*, dorsal view of three specimens, mantle opening in the upper part, stalk in the lower part of the figures; *d–f*, ventral view of the same specimens. ×18.

The animals are of very small size, their greatest diameter being about 2 mm., their antero-posterior diameter (in the median plane) about $1\frac{1}{2}$ mm., and their smallest (dorso-ventral) diameter less than 1 mm. The total diameter in the antero-posterior direction is, as a rule, slightly less than the greatest diameter. The outlines of three specimens in dorsal view are given in Fig. 1*a–c*, in ventral view in Fig. 1*d–f*. The shape of the parasites is more or less roundish or somewhat trapezoid or triangular; their contour is slightly irregular as the mantle shows a number of rather inconspicuous lappets. The comparatively wide mantle opening, which is surrounded by a well-developed muscular wall, is found on the anterior region of the dorsal surface. As a rule the dorsal surface shows a system of three shallow grooves running from

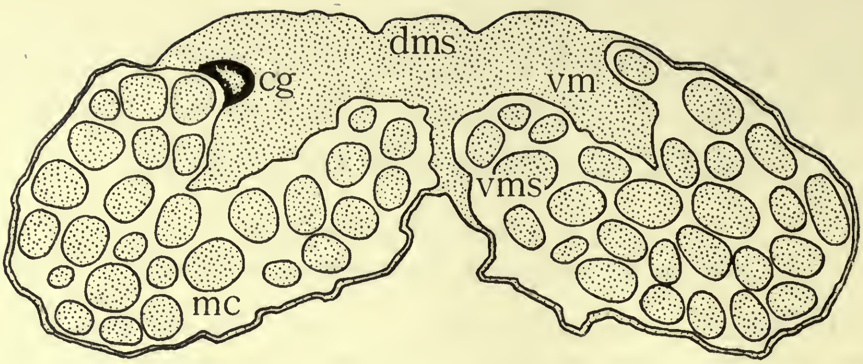

Fig. 2. *Lernaeodiscus pusillus*, specimen of Fig. 1*a*, *d*. Transverse section showing one of the colleteric glands (*cg*). *dms*, dorsal mesentery; *mc*, mantle cavity; *vm*, visceral mass; *vms*, ventral mesentery. ×60.

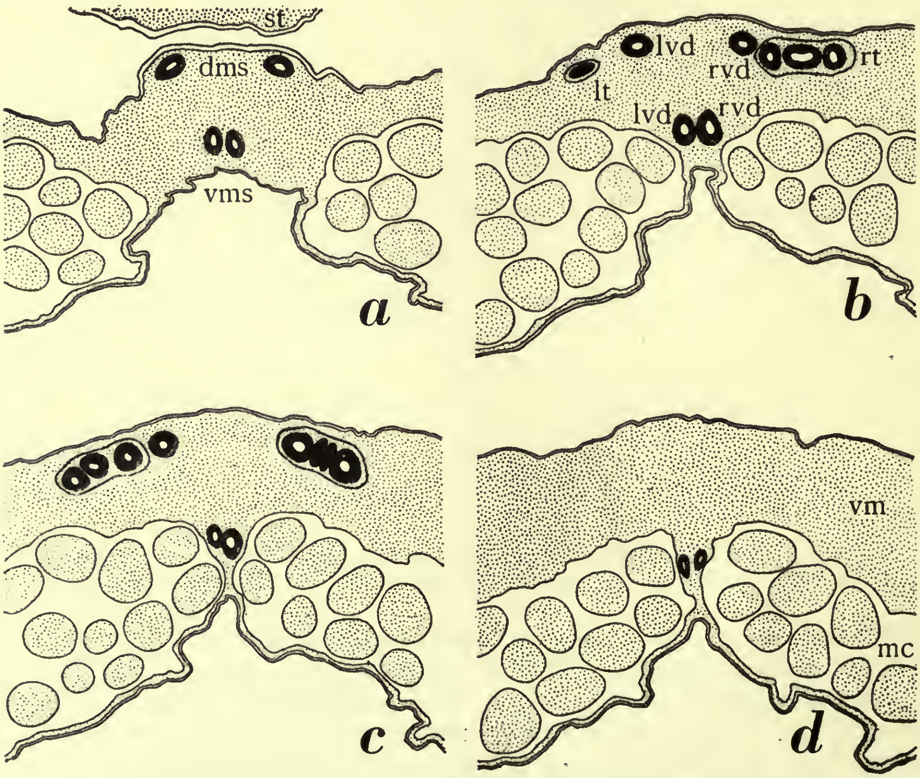

Fig. 3. *Lernaeodiscus pusillus*, specimen of Fig. 1*a*, *d*. Central parts of transverse sections, *a* from a region not far from the stalk, each following section from a more anterior region. *dms*, dorsal mesentery; *lt*, left testis; *lvd*, left vas deferens; *mc*, mantle cavity; *rt*, right testis; *rvd*, right vas deferens; *st*, stalk; *vm*, visceral mass; *vms*, ventral mesentery. ×64.

the centre to the mantle opening and to the lateral parts of the posterior region of the body. On the ventral surface there is a distinct groove running from the stalk in an anterior direction; this groove varies in length and in breadth.

The three specimens shown in Fig. 1 were sectioned transversely for the study of their internal structure. In sections from the region about half-way between the stalk and the mantle opening the colleteric glands are found; as a rule one of these is situated more anteriorly than the other. These glands (Fig. 2, *cg*) are more or less cup-shaped small cavities surrounded by an epithelium with a stronger affinity for stains than the surrounding parts. The figure further shows that the dorsal surface of the visceral mass is broadly attached to the mantle, in this way forming the so-called dorsal mesentery. On the other side the visceral mass is connected with the mantle by means of a real mesentery, the ventral mesentery. Where the latter is attached to the mantle there is, externally, the longitudinal groove referred to above.

In the three sectioned specimens the colleteric glands entirely agree with one another in shape, their position in the visceral mass, and their size. The male organs in two of the sectioned specimens are also similar in every respect (Fig. 3), but in the third specimen (Fig. 4) they are slightly more complicated.

The male organs closely correspond with those of *Lernaeodiscus okadai* Boschma (cf. van Baal, 1937, figs. 18–21). The male openings, in a region about half-way between the stalk and the mantle opening, are found on each side of the ventral mesentery (Fig. 4*d*, *e*). The vasa deferentia run along the ventral mesentery until they reach the posterior part of the visceral mass. Here they turn towards the dorsal surface (Figs. 3*a*, 4*a*), and continue their course along the dorsal mesentery in an anterior direction. After the vasa deferentia have passed into the testes the latter extend in a lateral direction, so that the terminal part of the testes is the most lateral part of the male organs (Fig. 3*b*, *c*).

As remarked above, the male organs in two of the sectioned specimens have a similar shape (as represented in Fig. 3); in the third specimen the male organs show some differences. Here the left testis (Fig. 4*d*, *e*) does not extend in a lateral direction, whilst the terminal part of the right testis after continuing its course in a lateral direction towards the right margin of the visceral mass (*a* in Fig. 4) obtains a curved shape by extending towards the median plane again (*p* in Fig. 4). The closed end of this testis consequently lies next to the right vas deferens (Fig. 4*b*).

Besides having a course in a lateral direction the testes in all the three specimens are strongly contorted, so that in sections they appear to be divided into numerous smaller parts.

It is rather difficult to define the characters by which *Lernaeodiscus pusillus* can be distinguished from the other species of the genus that are, like the new species, parasites of Porcelain Crabs, viz. *L. porcellanae* Müller (cf. Müller, 1862; Boschma, 1931) and *L. okadai* Boschma (cf. Boschma, 1935; van Baal, 1937).

The external shape of *Lernaeodiscus porcellanae* seems to be rather constant, the animal having well-developed lappet-like expansions of the mantle. But too few specimens are known to establish this peculiarity as a constant character for full-grown as well as immature specimens. In *L. okadai*, van Baal (1937) has shown that the external shape is subject to a very large amount of variation. Here, as a rule,

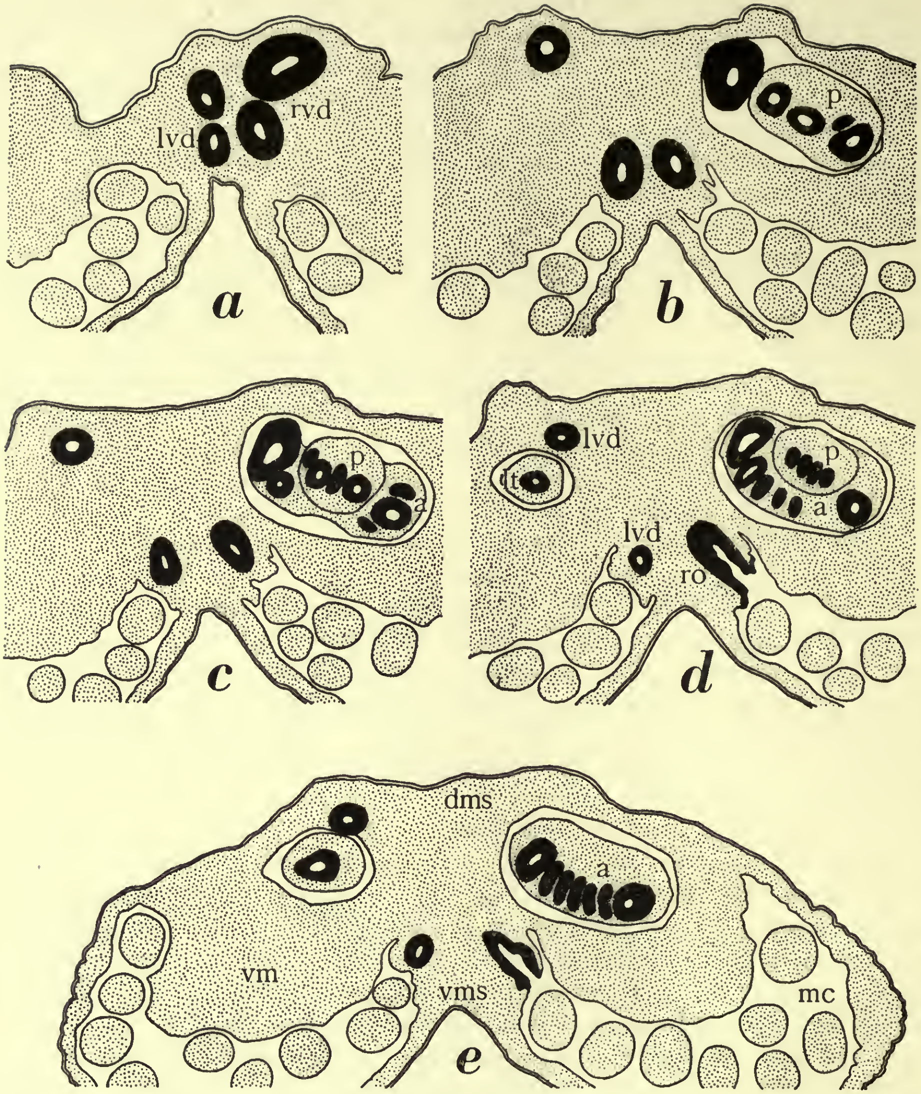

FIG. 4. *Lernaeodiscus pusillus*, specimen of Fig. 1*c*, *f*. Central parts of transverse sections, *a* from a region not far from the stalk, each following section from a more anterior region. *a*, anterior part of right testis; *dms*, dorsal mesentery; *lt*, left testis; *lvd*, left vas deferens; *mc*, mantle cavity; *p*, posterior part of right testis; *ro*, right male genital opening; *rvd*, right vas deferens; *vm*, visceral mass; *vms*, ventral mesentery. ×64.

the lappets do not occur in young specimens but are generally distinct in mature animals. The specimens of *L. pusillus* have, as far as their external shape is concerned, a rather constant appearance.

The colleteric glands in the genus *Lernaeodiscus* are of such a simple structure that they cannot furnish characters for specific distinction.

The male genital organs are, to a large degree, subject to individual variation, as is evident from van Baal's (1937) elaborate researches on numerous specimens of *L. okadai*.

The only remaining distinctive character is that of the size of the animals. On this character *L. porcellanae*, by its comparatively large size, is at once distinguished from *L. okadai* and *L. pusillus*. In *L. pusillus* the greatest diameter is about 2 mm., and the total length is but slightly smaller. The sectioned specimens are fully mature, as their mantle cavities contain large quantities of eggs. For *L. okadai* there are the following data (the numbers giving the length and the greatest transverse diameter in mm.) recorded by van Baal (1937):

$2\frac{1}{2} \times 3$ (small number of eggs); $4 \times 5\frac{1}{2}$ (no eggs); $4\frac{1}{2} \times 5$ (small number of eggs); 4×5 (large number of eggs); $2\frac{3}{4} \times 3\frac{1}{2}$ (very small number of eggs); $1\frac{1}{2} \times 2$ (no eggs); $6 \times 7\frac{1}{2}$ (large number of eggs); $3\frac{1}{2} \times 5\frac{1}{2}$ (no eggs); $2 \times 4\frac{1}{2}$ (many eggs); $2\frac{1}{2} \times 4$ (crowded with eggs); $5\frac{1}{2} \times 6$ (many eggs); $4\frac{1}{2} \times 6$ (many eggs); $4 \times 4\frac{1}{2}$ (many eggs); $2\frac{1}{2} \times 4$ (without eggs).

These data show that the specimens with numerous eggs are the larger ones in which at least one dimension reaches 4 mm. Moreover, when in large specimens no eggs are present in the mantle cavity they may have been recently discharged from this cavity. The data, therefore, give sufficient evidence for the opinion that *L. okadai* reaches its mature state at a stage in which at least in one dimension the body has a size of 4 mm. On the other hand, *L. pusillus* is fully mature at a size of 2 mm.

Summarizing it may be remarked that though the specific characters of *Lernaeodiscus pusillus* may appear unconvincing there is sufficient evidence for regarding the parasite as specifically distinct from the other forms belonging to the genus.

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PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

Parts appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 5, of the Zoology series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued November 1951 *Price Five shillings*

ON A RARE DEEP-SEA FISH *NOTACANTHUS PHASGANORUS* GOODE (HETEROMI-NOTACANTHIDAE) FROM THE ARCTIC BEAR ISLE FISHING-GROUNDS

By DENYS W. TUCKER, B.Sc.
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and

J. W. JONES, Ph.D.
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(*With Plates 7–9*)

INTRODUCTION

On the 27th of August 1949 the Fleetwood trawler *Wyre General* landed an unusual fish from the Bear Isle grounds. No information is available concerning the depth at which it was taken, but about 100 fathoms may be assumed from our knowledge of the fishery. Messrs. James Mitchell (Port Health Officer) and P. J. Fisher (Chief Sanitary Inspector), who have frequently been instrumental in obtaining rare fishes, kindly forwarded it to the Department of Zoology, University of Liverpool, where it was recognized as a rare *Notacanthus* and presented to the British Museum. The species is *N. phasganorus* Goode, new to the national collections. Only five other authenticated specimens are known, all in American museums, and of these but two have been described and figured.[1]

The holotype (U.S. National Museum, Washington, No. 25972; Goode (1881); Goode & Bean (1894 = 1896)) was taken from the stomach of a Ground-shark, *Somniosus brevipinna* Lesueur = *S. microcephalus* (Bloch & Schneider), on the Grand Bank of Newfoundland, and was partly digested and mutilated about the head. Bigelow & Schroeder (1935) describe a specimen trawled in about 100 fathoms, 20 miles south of Sable Island, which was in good condition except that the viscera had been removed, and the same authors mention a further example from the same locality (Museum of Comparative Zoology, Cambridge, Mass., Nos. 33946 and 35306 respectively).

[1] A large and originally well-preserved *Notacanthus* obtained in Iceland during the voyage of *La Recherche* and figured as *N. nasus* Bloch by Gaimard (1851, pl. XI) and by Cuvier (1836, pl. 55) has been tentatively referred to *N. phasganorus* Goode by Vaillant (1888*b*), who was able to examine the specimen (Musée National d'Histoire Naturelle, Paris, No. A. 6864). One of us (D.W.T.) visiting Paris in October 1950 was told by Prof. L. Bertin that it could not then be found. 'Très probablement a-t-il été détruit à une date ancienne (vers 1889)'. We have little doubt concerning the accuracy of Vaillant's identification, but do not regard the published figures and data available as sufficiently reliable for a critical determination. See Saemundsson (1949) for further discussion and a bibliography of Icelandic material.

In reply to a request for further information on his material Dr. William C. Schroeder disclosed that two more examples have since been taken: M.C.Z. No. 37027 in 420 fathoms at 42° 18′ N., 65° 01′ W., and No. 37037 in 100 fathoms at 44° N., 57° W. Dr. Schroeder is preparing a paper on the species in which these will be described and has kindly allowed us to use such unpublished data as are needed to establish the identity of the Bear Island specimen. We wish also to acknowledge the assistance of Mr. Ernest A. Lachner of the U.S. National Museum who re-examined the holotype for us. The illustrations to the present paper are (with the exception of Fig. 1) the work of Mr. Hubert Williams and the X-ray photographs were taken by Mr. P. E. Purves.

Modern papers by Matsubara (1938) on his *Notacanthus fascidens* and by Trotti (1939) on *N. bonapartei* Risso (based on the examination of 9 and 69 specimens respectively) have largely invalidated the taxonomic distinctions made by earlier workers, especially by Goode & Bean. Matsubara concludes:

'Among the characteristics used in the taxonomy of the fishes of the family Notacanthidae, the number of anal spines and the positions of the insertions and also end points of the fins, which are in reality most variable, are considered to be of most importance. . . .It would be superfluous to say that one must re-examine whether or not each known species belonging to the Notacanthidae is an independent species by taking the above mentioned variabilities into consideration.'

Trotti remarks similarly:

'Concludendo, la grande variabilità del profilo del muso e soprattutto la mancanza di persistenza del rapporto tra dorsali ed anali dure . . . ci porta ad una revisione dei caratteri differenziali dei rappresentanti del genere *Notacanthus* e *Gigliolia*.'

In publishing this full account of the new specimen (British Museum (Natural History), No. 1950.3.30.2) we hope to put on record material of value to such a subsequent revision, and to justify an identification which not only extends the known range of *N. phasganorus* from the western Atlantic to the Arctic but also provides the first published data on the bionomics of the species if not of the genus. But although we now identify our specimen with Goode's species, we are conscious that in the present state of the taxonomy of the genus this name may not be final. There is need of a critical re-examination especially of the material designated *N. chemnitzii* Bloch 1787, *N. nasus* Bloch 1795, *N. phasganorus* Goode 1881, and *N. analis* Gill 1883, the inter-specific differences between which, as at present described, do not seem greater than the intra-specific variation demonstrated elsewhere by Matsubara and by Trotti. It is probable that such a re-examination of the types of these four 'species' supplemented by observations from other material will confirm our suspicion that some or all may be identical. This is no new speculation (see, for example, Lütken, 1898), and it may reasonably be inquired why no precise solution has yet been given. The answer is that apart from the comparative paucity of material, aggravated by its wide dispersal in study-collections, even the type-locality of Bloch's material is not certainly established—though stated by him to have come from the East Indies it has since been believed to have come from Iceland—and the originally bad condition of the holotype has since further deteriorated. (Cf. accounts of Bloch himself, of Cuvier &

Valenciennes (1831), and of Hilgendorf in Goode & Bean (1896).) Even if the specimen in the Berlin Museum is still in existence, it is therefore exceedingly doubtful whether it retains characters adequate for a modern redescription of Bloch's species.

We have no more material relevant to that problem in the British Museum (Natural History), but hope in a subsequent paper to redescribe the types of *N. sexspinis* Richardson 1844 and *N. annectens* Boulenger 1904, and to give accounts of the series of these and related species in our collections as a contribution towards a future full revision. A forthcoming report on the Notacanthidae collected by the Danish *Thor* Expeditions in the north-eastern Atlantic will provide further material.

DESCRIPTION

Although the body is very well preserved, three factors seriously complicate the usual table of measurements. Firstly the fish is a spawning female, greatly distended by a mass of ripe eggs: as a consequence the vent is widely dilated, blocked by a large plug of ova, and opens posteriorly rather than ventrally, while the postero-lateral walls of the abdomen project as a pair of pouches which partly embrace the vent and conceal the origin of the spinous anal fin. This general distortion of the abdomen renders measurements of body-height of doubtful value. Secondly, the head of the specimen is markedly downturned in a very 'Mormyrid' fashion and more so than in any figure or specimen of a Notacanthid that we have seen. Though there is little support for our opinion forthcoming from other specimens of *N. phasganorus* we are satisfied that the X-ray photograph published as Plate 8 and other considerations (dentition+diet, position of operculum in relation to gill-opening) indicate that this may at least be adopted as a natural attitude, even though it may not be the attitude of rest. Accordingly we give two measurements for body-length and other distances from the tip of the snout to various points; the first represents the measurements with the head forced into line with the body, the second with it *in situ*. Statements of body proportions are based on the former to facilitate comparison with other accounts; the corresponding duplicate set may be computed from the data given if desired. Thirdly, there is some doubt regarding the tail, which may have had the tip broken off and subsequently regenerated a caudal fin. In this case it would be necessary to allow about another 5 cm. on the standard length, plus 2–3 cm. for the caudal fin.

Measurements

Total length	970	mm.	(950)
Standard length	945	,,	(925)
Body:			
Depth at pectoral	140	,,	
,, pelvics	170	,,	
,, vent	140	,,	
Greatest depth	180	,,	
Greatest breadth	50	,,	
Length, snout to vent	422	,,	(402)

Measurements (contd.)

Head:

Length	122 mm.	
Greatest depth	92 ,,	
Greatest breadth	50 ,,	
Interocular width	25 ,,	
Length of snout	35 ,,	
,, postorbital region	80 ,,	
,, upper jaw	36 ,,	
,, mandible, to hind end of articular	39 ,,	
Breadth of gape	41 ,,	
Length of maxillary spine	6 ,,	
Diameter of eye	21 ,,	
Longest gill-raker	6 ,,	

Dorsal:

Distance from snout	352 ,,	(350)
Length of base	235 ,,	
Horizontal distance from pelvics	12 ,,	

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
Lengths of spines	1	6	7	8	8	9	11	12	10	13	14	mm.
Intervals between spines	6	15	20	21	24	23	22	21	14	11		mm.

Length of soft ray	7 mm.	

Anal:

Distance from snout	432 ,,	(412)
,, vent	10 ,,	
Length of base	540 ,,	
,, spinous base	230 ,,	
,, first spine	2 ,,	
,, longest spine (XVIII)	19 ,,	
,, ,, soft ray	34 ,,	

Pectoral:

Distance from snout	148 ,,	(139)
Length, left	65 ,,	
,, right	56 ,,	

Pelvic:

Distance from snout	350 ,,	(330)
,, base to vent	70 ,,	
,, tip	24 ,,	
Length	46 ,,	

Caudal:

Distance from tip to dorsal	390 ,,	
Length	25 ,,	

Radial formula D. XI–1; A. XX, 101+; C. 12(?); P. 13; V. III, 7.
Gill-rakers on first arch 3+1+13.
Branchiostegal rays 9.
Vertebrae 185. (Nos. 75 and 80 have double centre.)
(All counts from X-ray photographs.)
Scales along lateral line, about 500.
Scales in transverse series, 31 above lateral line, 58 below.
Pyloric caeca destroyed through decomposition.

Length of the head 7·95 times in the total length; depth at pectoral 6·92; depth at pelvic 5·70; distance from tip of snout to dorsal 2·75; from tip of snout to pectoral 6·55;

from tip of snout to pelvic 2·77; from tip of snout to vent 2·29; tip of snout to anal 2·24; from tip of caudal to dorsal 2·48; base of dorsal 4·12; spinous base of anal 4·21.

Snout 3·48 in head; eye 5·80; postorbital part of head 1·52; upper jaw 3·38; interocular space 4·88; mandible 3·12; pectoral 1·87; pelvic 2·65.

Body elongate, compressed, considerably higher at the pelvics than at the pectorals, even allowing for the distension of the abdomen; the greatest breadth 0·35 the height at the vent; tapering posteriorly into a long slender tail.

Head compressed, shorter than depth of body, 2·46 in the trunk and 3·54 in the length from tip of snout to anal. Snout long, fleshy, 1·4 times the interocular width and 1·66 times the diameter of the eye. Interocular space narrow, strongly convex, 1·19 times the diameter of the eye. Eye covered by semi-transparent skin, lacking an orbital fold. Nostrils close together, much nearer eye than tip of snout, the posterior slit-like, one-third the eye's diameter from the orbit, the anterior opening into a thin-walled tube protected by a small flap. The centres of the eye, of the two nostrils, and the tip of the snout lie on a straight line.

Mouth inferior, broad, gently curved; upper jaw nearly as long as length of snout; maxilla with a posteriorly directed pungent spine on its upper margin, extending to below the middle of the eye. The integument of the mandible forms a labial fold on each side.

Teeth (Pl. 7, fig. 4) in the upper jaw in a single row, 37 on each side, slender, inclining inward, the bases cylindrical, the tips antero-posteriorly flattened and introrse, mesially 3 mm. long, gradating into smaller and simpler lateral ones. Palatines movable vertically with two rows of about 25 rather finer teeth on each side, with sharper markedly introrse tips. Mandible with a complete innermost row of about 30 teeth on each side, resembling those of the upper jaw but more delicate, preceded by two irregular rows of fine aciculate teeth which do not extend as far laterally as those of the main series. All teeth more or less movable. Anteriorly the teeth of the upper jaw bite between the two series of the lower, but owing to the greater radius of curvature the posterior teeth bite outside those of the mandible. The palatine teeth engage with those of the lower jaw. No vomerine teeth.

Gill-openings wide, membranes separate and free from isthmus. Gills four; no pseudobranch visible on superficial examination. Gill-rakers slender, pointed, incurved, well separated, having minute bristles on their inner faces; a little more than half the length of the gill-filaments, the longest 3·50 in the diameter of the eye.

The prominent pores of the lateralis system of the head are distributed thus: 3 in the supra-temporal series, and on each side 5 in the supra-orbital (comprising 2 above the eye, 1 above the posterior nostril, 2 before the anterior nostril), 16 in the infra-orbital and 14 in the preoperculo-mandibular series.

Lateral line gently arched over pectoral, following profile of the back, thence dropping obliquely to one-third the depth of the body over the vent, and further descending nearly to a median position at the point where it disappears two-thirds of the way along the tail. Lateral line pores conspicuous with darkly pigmented lips.

Entire body scaled, even to the lips, except for the hinder margin of the operculum. Scales cycloid, rectangulo-ovate, closely inset in tough sheaths; very small on the head ($1{\cdot}2 \times 1{\cdot}0$ to $2{\cdot}2 \times 2{\cdot}0$ mm.), increasing in size posteriorly to a maximum

of $4{\cdot}5 \times 3{\cdot}7$ mm. on the middle of the body, and thereafter becoming progressively reduced until half-way along the tail they equal those of the head.

Pectorals vertically inserted at middle of body-depth, at a distance behind the gill-opening equal to length of own base; bases broad, fleshy, scaled, pedunculate; posterior edge of fin rounded, length slightly more than half length of head.

Pelvics (Pl. 7, fig. 3) closely adjacent, separated by a narrow groove, reaching far short of the vent. Bases fleshy, pedunculate, thickly covered with scales, origin very slightly behind vertical through origin of dorsal, posterior edge rounded. The third pelvic spine has two much smaller ones set against its base, the first of these concealed by skin.

First dorsal spine (Pl. 9, fig. 6) hidden under the skin; last dorsal spine the longest, followed by a recurved soft ray (Pl. 9, fig. 7) set in a fleshy protuberance. There is a slight groove between the bases of the spines and each supports a slight membrane posteriorly which is best developed between the last spine and the soft ray.

The anal commences immediately behind the vent and below the Vth dorsal spine; the XIIIth anal spine lies under the last dorsal. The anal spines are embedded in fleshy tissue (the first completely concealed, Pl. 9, fig. 8), from which successive spines emerge farther and farther.

Caudal (Pl. 9, fig. 9) clearly separated from anal, but lacking a distinct peduncle and probably aberrant owing to regeneration of tip (see p. 75).

Colour. Head and body dark brown, tending to be lighter on the forehead and flanks; lips and hinder edge of operculum bluish-black, fin-rays and anal fin dusky. The fish had a glossy, varnished appearance when dry. Peritoneum and stomach and inside of buccal cavity and operculum black, intestine cream.

COMPARISON WITH SPECIMENS PREVIOUSLY DESCRIBED

The original description of the holotype (Goode, 1881) gives the radial formula D. X; A. XIX (130); C.0; P. (17); V. II, 8–9. Mr. Lachner was asked to re-examine the dorsal, pectoral, and spinous anal fins only, ascertaining whether any concealed spines and rays had been overlooked and whether a count of the pectoral rays obtained by means of an incision across the fleshy base required any modification of the above formula. He finds the right pectoral fin wanting and gives the count for the left: the revised formula now reads:

Holotype: D. X–1; A. XIX, 130; C.0; P. 18; V. II, 8–9.

compared with:

M.C.Z. No. 33946 D. XI–(?); A. XXIV, 127; C. 7; P. 17; V. III, 7.
New specimen, D. XI–1; A. XX, 101+; C. 12(?); P. 13; V. III, 7.

Bigelow & Schroeder give A. XX for M.C.Z. No. 35306. Schroeder, *in lit.*, provides the following additional data:

M.C.Z. No.	35306	P. 16. One soft ray in dorsal.
,,	37027	P. 13. One ,, ,,
,,	37037	P. 16. Two soft rays in dorsal.
,,	33946	Not available for re-examination.

Bearing in mind the known variation in other species we may regard the counts for

dorsal, ventral, and spinous anal fins as giving an adequate agreement.[1] The range of variation in the pectoral (13–18) is remarkable, however, even compared with Trotti's counts for *N. bonapartei* (12–14) and Matsubara's for *N. fascidens* (12–15). The discrepancies in the counts given for the caudal in part reflect the curious misunderstanding which has surrounded the problem of the tail structure in this group. The diagnoses of Goode & Bean (1894) contain mutual contradictions:

Fam. Notacanthidae. 'Anal fin . . . extending . . . to the caudal with which it unites.'

Notacanthus. 'No caudal', although under the same generic diagnosis *N. sexspinis* is given a count of C. 5. In the accounts of the various species several numbers are given, including *N. phasganorus* with C.o.

Regan (1929) gives:

Order Heteromi. 'A long tail, with a long anal fin below it, tapering to a point, without caudal fin.'

While the relations of anal and caudal are certainly difficult to ascertain in these fishes and really call for radiographs and alizarin preparations for their proper elucidation, there can be no doubt that many previous descriptions made before the use of the binocular microscope became *de rigueur* will prove to be erroneous when the material is re-examined.

The present specimen shows a distinct separation between the caudal and anal rays, more easily studied in an X-ray photograph (Pl. 9, fig. 9), which shows at least 12 caudal rays. But the structure is markedly different from that of the tails of other species which we have examined, which are symmetrical, having a distinct though small caudal peduncle, already described and figured in *N. phasganorus* by Bigelow & Schroeder (1935). The appearance presented in our figure suggests that the tail has lost its tip at some time and subsequently regenerated a caudal fin.

Since Goode almost certainly included the caudal rays in his count for the anal fin (130) we should do likewise to obtain a comparison, and so have 134 for the fish described by Bigelow & Schroeder and 113+ for the new specimen. A truncation of the tail would also account for this lower number.

Gaimard's (1851) figure of the *La Recherche* specimen evidently represents a tail even more markedly truncated (Vaillant, 1888*b*) and again with a regenerated caudal fin. It seems that this condition is not uncommon in *Notacanthus*.

[1] Vaillant's (1888*b*) data, supplemented by counts from Gaimard's (1851) plate, give the radial formula:

D. XI–1; A. XXII, 92+; C. 8 (?); P. 16; V. III, 8

for the *La Recherche* specimen, which therefore comes within the known range of *N. phasganorus*.

For further comparison the following counts all purport to have been taken on the holotype of *N. nasus* by Bloch (1795), Cuvier & Valenciennes (1831), and Hilgendorf for Goode & Bean (1896) respectively:

D. X; A.+C. XIII, 136; P. 16; V. II, 8.
D. X–O; A. XIII, 116; C. 8; P. 17; V. I, 8.
D. XI; A. XV, 118; C. ?; P. 19; V. III, 7 (l), 8 (r).

There seems to be little useful purpose in attempting to decide the relation between *N. nasus* and *N. phasganorus* on such data, except to remark that the only serious discrepancy, the consistently low count for the spinous anal, must be considered against the range of A. IX–XVIII demonstrated by Trotti (1939) in *N. bonapartei*, and the anterior fin-structure shown in our Pl. 9, fig. 8.

ANATOMY

Those skeletal features discernible from X-ray photographs agree with the very full accounts given by Günther (1887) for *N. sexspinis* and Vaillant (1888*a*, *b*) for *N. mediterraneus*. Vaillant gives the more detailed account of the general anatomy. The viscera in the present specimen are in general poorly preserved, but it is possible to supplement these descriptions in certain details.

The spacious body-cavity is very high, and extends posteriorly considerably behind the anus, to the level of the seventh anal spine. The kidneys are large, the deep anterior lobes flanking the rectum and not extending farther forward in any

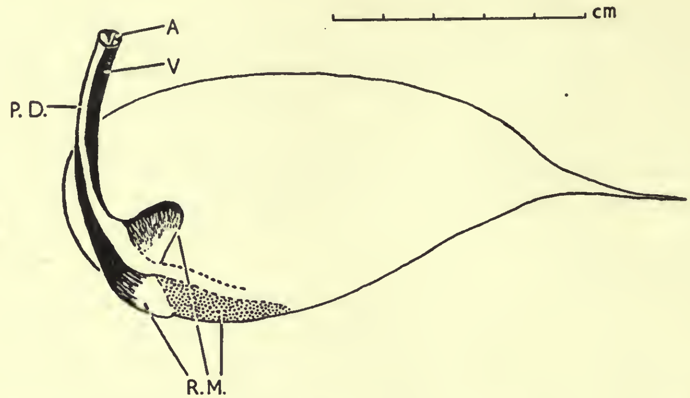

FIG. 1. Gas-bladder from left side. P.D., pneumatic duct; A. and V., artery and vein supplying bladder; R.M., retia mirabilia. The dotted portions indicate the extensions of the pneumatic duct and of one rete within the bladder.

bulk, while the remainder of the kidneys extend back along the roof of the post-anal body-cavity. There is no urinary bladder preserved. The undivided liver, the gonads, and the alimentary canal appear to agree with previous accounts, but the gas-bladder shows some marked differences and merits fuller treatment. Whether the discrepancies are due to interspecific variation or to inaccuracies of description cannot be stated.

The gas-bladder (Fig. 1) is oval in shape with a small blind posterior prolongation, and lies above and extends slightly before the ventral fins. It is suspended in a fold of mesentery with a rather stronger attachment posteriorly; the bulk of it being free anteriorly sags down into the body-cavity. The tunica externa comprises the usual two easily separable layers: an outer thin, tough, white, and muscular and an inner very dense and silvery, containing elastic fibres. The tunica interna comprises a substantial basis of dense connective tissue supporting a poorly preserved series of muscular, vascular, and columnar epithelial layers. The lumen of the bladder contains a quantity of granular yellow matter.

There is a fairly long pneumatic duct which does not approach anywhere near the oesophagus. Along it run the artery and vein supplying the bladder, and a number of streaks of yellowish tissue interpreted as pancreas. The vessels break up into two retia mirabilia before approaching the bladder with the pneumatic duct on the lower

left side, the combination of these structures forming a laterally compressed body which Günther regarded as a left 'cornu' of the bladder, the retia evidently being identical with his 'pair of thick muscle-like pads'. The pneumatic duct opens in the centre of the floor of the bladder towards the anterior end. The retia are of the 'rete mirabile unipolare duplex' type (Woodland, 1911, 1911*a*), since dissection does not reveal any recombination of capillaries to form major vessels before they enter the gas-gland. The gas-gland is a small patch of spongy vascular tissue surrounding the entrance of the pneumatic duct from which similar tracts radiate over most of the lining of the bladder. The postero-dorsal portion of the bladder has a thinner, smoother lining epithelium which probably represents a fully dilated oval (Woodland, 1913).

BREEDING

Though the precise date of capture is not available it may be assumed that the fish was taken about mid-August, and that the breeding season in Bear Island waters is therefore about that time.

The ova, entangled in fibrous tissue, were opaque white when received and slightly elliptical, ranging from $1{\cdot}20 \times 1{\cdot}30$ down to $1{\cdot}16 \times 1{\cdot}25$ mm. diameter. They thus provide a further instance of aspherical teleost eggs to be added to those discussed by Breder (1943). They contain many small colourless oil droplets, 10–70μ in diameter.

FOOD AND FEEDING

The stomach was well filled with the remains of some two dozen pink and magenta-coloured Actiniarians, comprising the tops of several small anemones of 1–2 cm. diameter and pieces apparently bitten from the rims of much larger ones. In some cases it was possible to distinguish scapus and scapulus; all the fragments were more or less heavily tuberculated and bore traces of a dehiscent cuticle.

A consideration of structure in relation to diet leads to some interesting conclusions.

1. The dentition and shearing bite of the jaws are admirably suited to feeding on Actiniarians. What would, on theoretical considerations, seem the ideal shape of the head and position of the mouth? A terminal mouth would require the fish to stand on end in the water when feeding, a rather unlikely proceeding, or to perform movements like those of the Lemon Dab *Pleuronectes microcephalus* Donovan which removes tubicolous polychaetes from their burrows by 'bringing its mouth down almost vertically upon its victim by a strong arching of the anterior part of the body' (Steven, 1930). (The same species in the southern North Sea feeds largely on *Cerianthus* sp.; Todd, 1907.) This last movement is hardly possible to a stout-bodied fish such as our *Notacanthus*. There remains only the combination of an inferior mouth with what degree of flexure can be attained, the condition in fact which is illustrated in Pl. 8, where there is a marked downturning of the vertebral column bringing the jaws into the best position for horizontal and near-horizontal biting. From these considerations, accompanied by the fact that there is no indication of any fracture or dislocation of the skull and pectoral region, we believe that the head of our specimen is in fact being carried in a normal position, though whether this is facultative or permanent cannot be decided.

2. The pieces of anemones present fall, as we have noted, into two size-groups, those from very small and very large individuals. The absence of remains of medium-sized ones suggests that such animals are possibly too large to be taken entire and yet too small to allow the fish to take a bite because the curvature of their body surface is so sharp that the jaws at maximum gape cannot obtain sufficient hold. With larger anemones it becomes possible to take a bite from the rim.

3. Günther (1887) remarks of *N. sexspinis*:

> 'The osseous framework of this fish is so much wanting in the characteristic peculiarities of bathybial fishes as to throw serious doubts that this species at least of *Notacanthus* lives at a great depth.'

The evidence from radiographs indicates that the skeleton of *N. phasganorus* is substantially similar, and its gas-bladder is better developed than in oceanic fishes. But from its diet and the related structural adaptations it is clearly a bottom-feeding form, and it is therefore probable that specimens taken have been obtained on or near the bottom, so that a bathymetric distribution of 100 to at least 420 fathoms may be deduced from the records so far available. *N. mediterraneus* Fil. & Ver. is evidently another bottom-feeding form; Vaillant (1888*b*) records hexactinellid sponge spicules from a specimen taken by the *Talisman* from more than 1,200 metres.

Actiniarians have been reported as of frequent occurrence in Cod stomachs obtained from Bear Island and the Murman coast (Brown & Cheng, 1946); off Greenland, where Cod from deep water off Nuk feed almost entirely upon them (Jensen & Hansen, 1931), and in Danish waters (Blegvad, 1916). Stephenson, in Brown & Cheng, loc. cit., provisionally identified their material as *Hormathia digitata* (O. F. Müll.), *H. nodosa* (Fabr.), and *Tealia felina* (L.) var. *lofotensis* (Dan.). Some of our material may be referable to *Hormathia* spp., but precise identification would be extremely difficult if indeed possible.

PARASITES

The gills, alimentary canal, and peritoneum lining the body-cavity have been examined for parasites, but none have been found.

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PLATE 7

Fig. 2. *Notacanthus phasganorus* Goode; Bear Island specimen.

Fig. 3. Detail of right pelvic fin, from below.

Fig. 4. A, underside of head; B, side, and C, D, front views of teeth of maxillary series; E, palatine tooth.

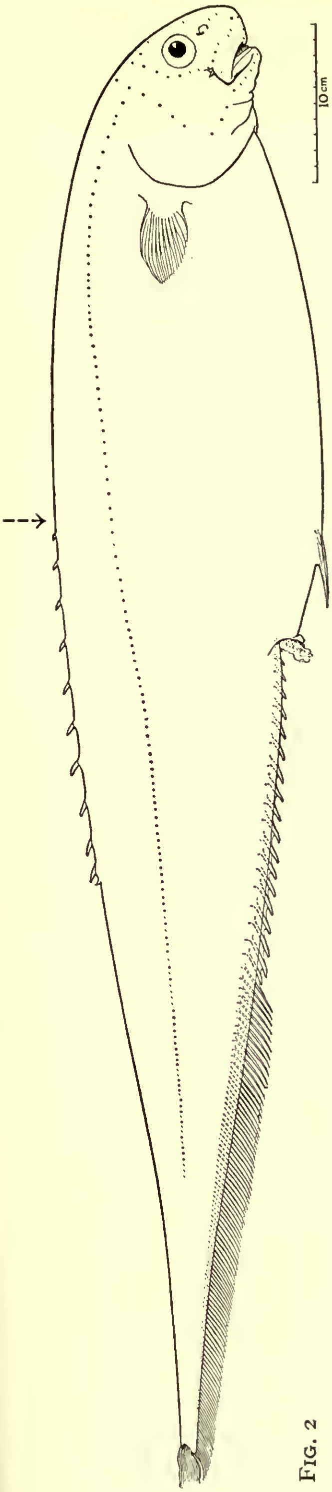

FIG. 2

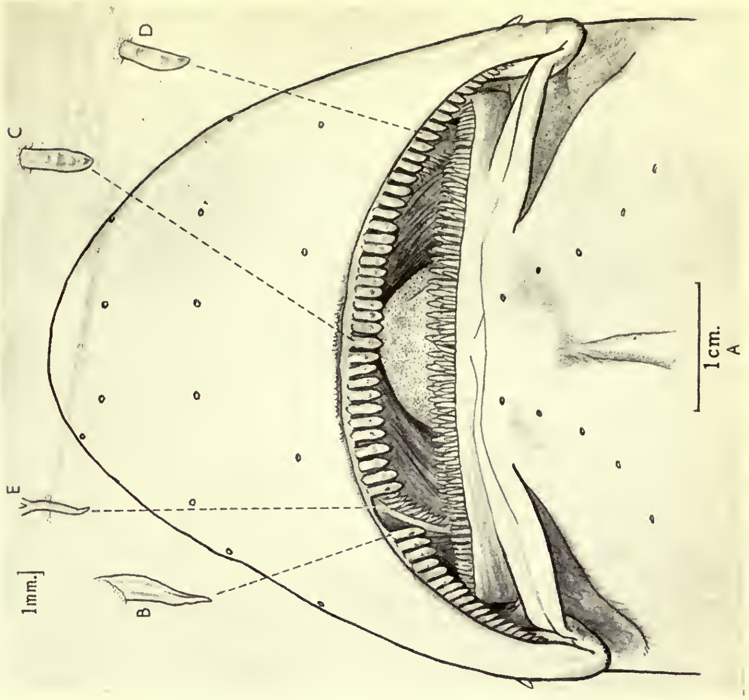

FIG. 4

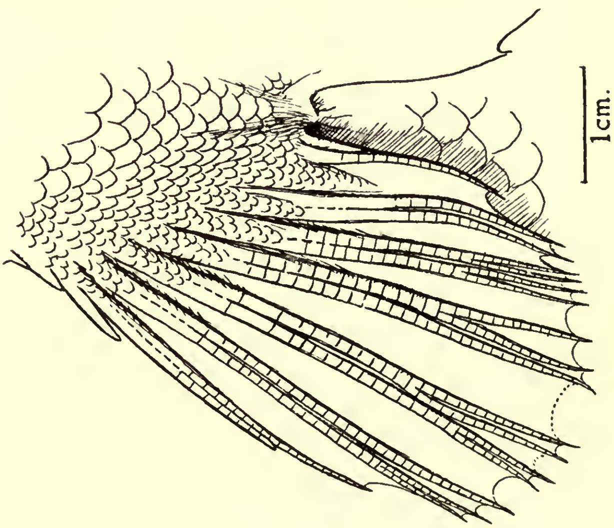

FIG. 3

NOTOCANTHUS PHASGANORUS

PLATE 8

FIG. 5. Unretouched X-ray photograph of head, showing flexure of vertebral column.

FIG. 5

NOTOCANTHUS PHASGANORUS

PLATE 9

Fig. 6. X-ray photograph of origin of dorsal fin.

Fig. 7. X-ray photograph of end of dorsal fin. I, II, &c., spines; R, soft ray.

Fig. 8. X-ray photograph of pelvic region, showing pelvic fins and girdle. AI, first spine of anal fin.

Fig. 9. X-ray photograph of end of tail.

(Figs. 2–4, scale indicated on drawing; Figs. 5–8, ×1; Fig. 9, ×2.)

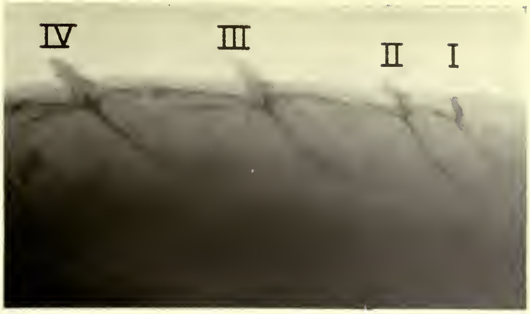

FIG. 6

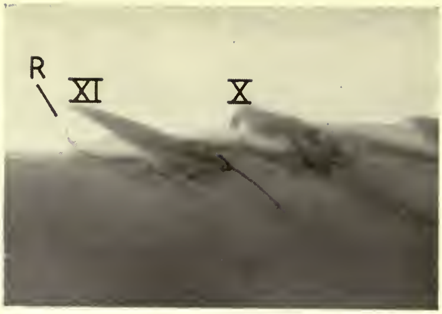

FIG. 7

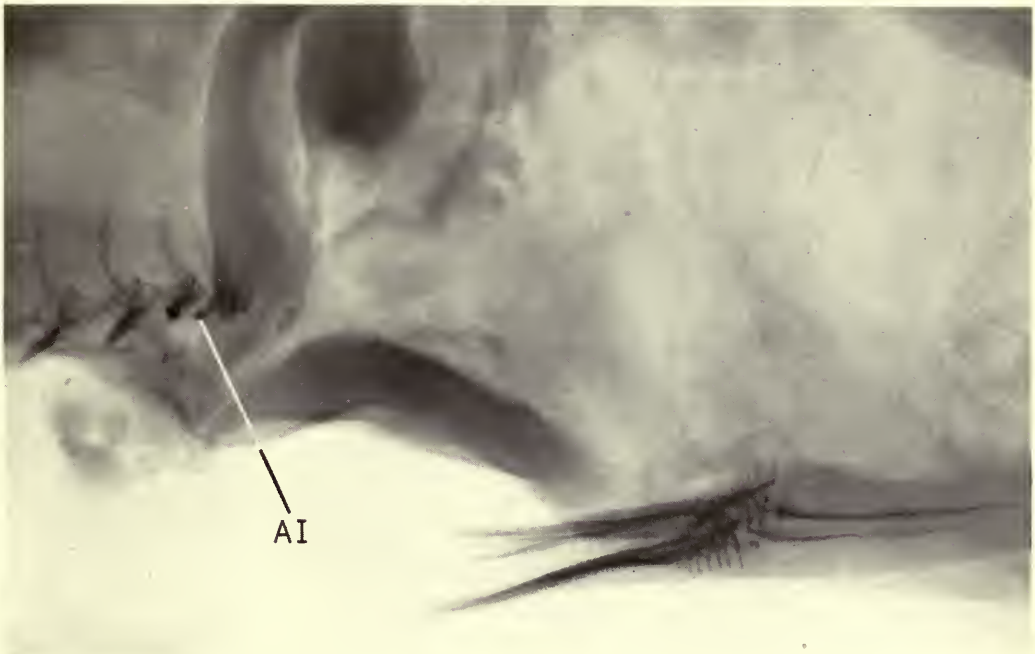

FIG. 8

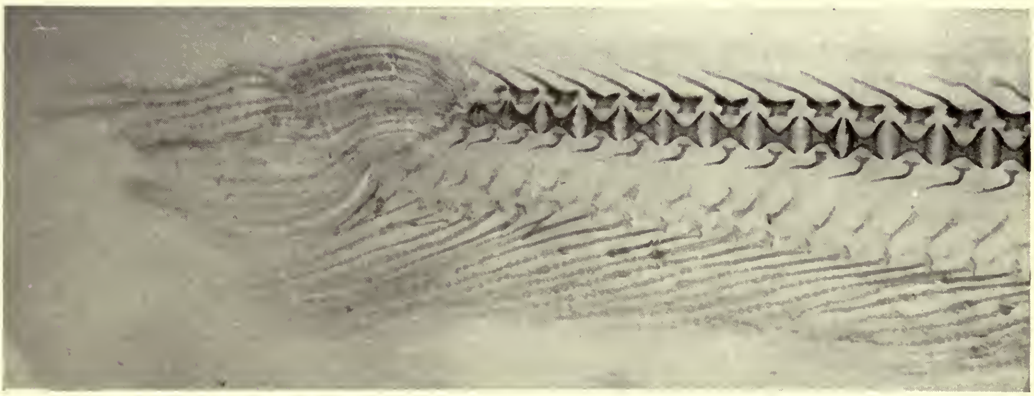

FIG. 9

NOTOCANTHUS PHASGANORUS

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BULLETIN OF
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LONDON: 1951

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Pp. 87–121; 18 *Text-figures*

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Issued November 1951 *Price Seven Shillings and Sixpence*

THE OCEAN SUNFISHES (FAMILY MOLIDAE)

By A. FRASER-BRUNNER

SYNOPSIS

The relationships of the Molidae with other Plectognathi are briefly discussed. The movable lobe at the hind margin of the body, supported usually by migrant dorsal and anal rays but sometimes also by caudal rays centrally, is designated the 'clavus'. Three genera are recognized, assigned to two subfamilies. *Masturus* is shown to include two forms (treated as species but possibly the sexes of one). Evidence is presented to show that in this genus alone of the family some caudal rays are developed. *Mola* is shown to include two species, which are diagnosed and figured. Sexual dimorphism in *Mola mola* is described. Full synonymies are included.

ON account of their curious form and the great size which they often attain, the fishes of the family Molidae, usually called Ocean Sunfishes, have attracted considerable attention from early times. A large and scattered literature exists concerning them, but although comparative studies have been made from time to time and their anatomy has received attention quite frequently, we are still far from a complete understanding of their relationships. This is mainly because all the species are rather rare, and their occurrence unpredictable, so that it is not possible to make an excursion for the express purpose of collecting specimens, as could be done with many other fishes, while the great size of most examples makes transportation and preservation a difficult problem. Consequently good comparative material is not easily available for study, and much reliance has to be placed upon published descriptions and figures.

It is the purpose of the present work to draw attention to certain facts which have become apparent from a study of the literature, aided by the material in the national collection.

My thanks are due to Mr. G. Palmer for his assistance in seeking out some of the references and checking a number of points in them.

I am concerned here only with taxonomy within the family, since a full consideration of their relationship to other Plectognathous fishes will be included in a larger work upon the anatomy and phylogeny of the whole Order now in preparation. It can be pointed out here, however, that I have already indicated in an earlier paper (Fraser-Brunner, 1943), that the Molidae are not really as highly specialized as previously supposed. Their main peculiarity lies in the atrophy of the rear end of the vertebral column, resulting in a mechanical rearrangement of the median fin-structures closely resembling that seen in other fishes when the tail is amputated at an early age; some interesting examples of this among Flatfishes have been given by Chabanaud (1935). The resemblance is not quite perfect, since with amputation the supporting bones of dorsal and anal fins are lost with the tail, whereas in the Molidae only the vertebral structures are lost.

The *lateralis* muscles of the trunk, deprived of their normal attachment, become inserted upon the deep muscles of the dorsal and anal fins, and progressively lose their identity in the genera *Ranzania*, *Masturus*, *Mola*. The result of this is that body-flexion is lost but the dorsal and anal fins gain in power, and the latter are therefore

the principal means of locomotion. The posterior parts of these two fins extend round the rear end of the truncated body to support a broad, stiff lobe which acts as a rudder. This has been called the 'pseudo-caudal' by Raven (1939 *a*), but this is not a very suitable term in my opinion; any structure in this part of the body may be described as 'caudal', and even if 'pseudo-caudal fin' is used, this is not true for all the species, for I hope to demonstrate on a later page that remains of the true caudal fin are included in the structure in *Masturus*.

For this rudder-like lobe at the end of the body in the Molidae I therefore propose using a new term, and throughout this paper it will be called 'the clavus' (Lat. *clavus*, a rudder).

Apart from these changes of form, all of which are demanded as mechanical consequences of the phyletic atrophy of the posterior part of the vertebral column, the Sunfishes resemble in their anatomy the more primitive of the Tetraodont fishes, and in one feature at least, the retention of the fourth gill, they are less modified even than those. They stand, therefore, near the main stem of the Tetraodonts, and attempts to derive them from the highly modified Diodontidae seem to me to be very far-fetched; whatever resemblances the latter may show are more plausibly explained by the assumption that they are evolved from a *Mola*-like type (before caudal atrophy) rather than the reverse. The Molidae show also some features in common with the Ostraciontoidea alone among Plectognathi, and indicate therefore the divergence of the Trunkfishes and Puffer-fishes from a common stock during their evolution.

In my classification of the Tetraodontoidea I expressed the view that only two genera of Molidae should be recognized. This was based on the belief, current at that time, that *Ranzania*, *Masturus*, and *Mola* were each represented by a single species, and since the latter two forms seemed to be more closely related to each other than to *Ranzania*, it appeared that this relationship would be better expressed by placing them together in the genus *Mola*. A more detailed examination of these fishes, however, has caused me to modify these views.

Firstly, I find that there are two species of *Mola* in the limited sense—one of world-wide distribution and the other apparently restricted to the Australasian region. Whitley (1931) recently revived the name *Mola ramsayi* Giglioli 1883 for the latter, but was apparently unaware of its distinguishing characters and assumed that all specimens from that region should be so named, whereas his main description appears to be of *M. mola* and the records show that both *M. mola* and *M. ramsayi* are to be found around Australasia. The type of *M. ramsayi*, a huge stuffed specimen, is in the British Museum (Natural History), and by a piece of good fortune one of our spirit-specimens belongs to that species, so that I have been able to make direct comparison with examples of *M. mola* of similar size.

Secondly, a close study of the literature concerning *Masturus lanceolatus*, aided considerably by the excellent work of Gudger on this subject, reveals that two forms are included here also, though it is not certain that they are different species. More interesting is the apparent fact that in *Masturus* alone of the family a remnant of the caudal fin is included in the support of the clavus. In this and in its musculature it is a little less specialized than *Mola*, and it therefore now seems desirable to recognize

it as a distinct genus in order to express its relationship to the other genera more clearly.

There has been much speculation in the past as to whether the rays supporting the clavus belong to the caudal fin or to the dorsal and anal, and even Gregory & Raven (1934), when describing the anatomy of *M. mola*, thought them to be caudal although their description and figure indicate that they are not (an error corrected by Raven in 1939). Apart from internal anatomy, the number of these rays is in most cases against the likelihood that they all belong to the caudal fin; in most Plectognathi

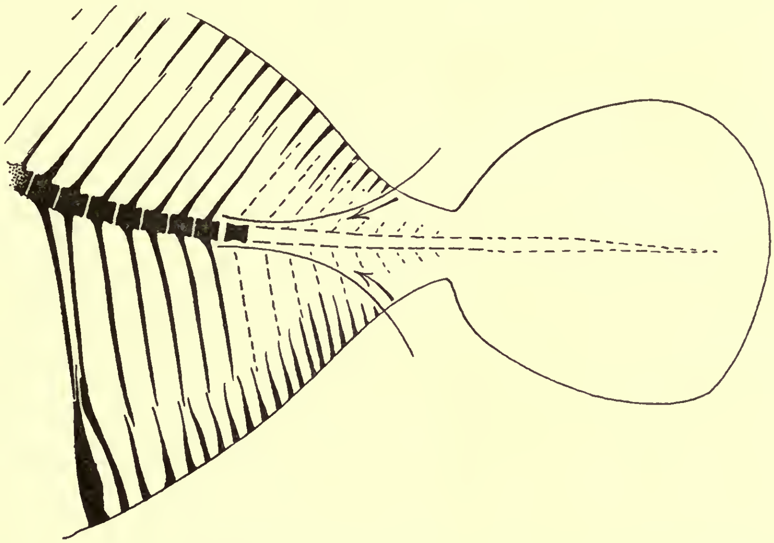

FIG. 1. Diagram illustrating reduction of the caudal region in the Molidae.

Persistent parts of the axial skeleton shown in black; atrophied parts shown with broken line; the last interneural and interhaemal bones close in along the lines marked with arrows. (Based on Ryder, 1886, modified by reference to adult and larval forms.)

there are only 12 caudal rays, exceptionally 13, and sometimes as few as 10. But in *Ranzania* and *Masturus* the clavus is supported by 20 or more rays, in *Mola ramsayi* by 16, and only in *Mola mola* by 12.

These rays are, in the main, supported by elements which have all the appearance of belonging to the series of interspinous supports of the dorsal and anal fins, but have been rotated to lie roughly at right angles to the last normal vertebro-interspinous complex by the process which has already been suggested by Ryder (Fig. 1). The skeletal supports of the clavus are accompanied by muscles which have split off from the inclinators of the dorsal and anal fins, and caudal muscles appear to have been lost with the posterior vertebral structures. Reduction of the caudal region can be shown to extend to the number of rays supporting the clavus. Thus in *Ranzania*, which has 18 remaining vertebrae, there are 22 rays of dorsal and anal origin in the clavus; in *Masturus* and *Mola*, which have 17 vertebrae, we find the series: *Masturus* 14–18 (exclusive of caudal rays), *Mola ramsayi* 16, *M. mola* 12.

Alongside this the form of the rays is of interest (see Barnard, 1935). In *Ranzania*

each ray in the clavus (except the outermost) is abruptly branched at its distal end (like those of the dorsal and anal lobes) and forms a fairly stiff fan-shaped support, closely apposed to those each side of it. In *Mola* this branched portion becomes hyperossified into a single plate or ossicle characteristic of the genus, the number and arrangement of these ossicles being of importance in specific diagnosis.

In *Masturus* the rays seem never to be branched in adults, and are never ossified distally, but in young examples they may be branched at the tip like those of *Ranzania*. This development can be seen by comparing the figures accompanying this paper. Between the rays in *Ranzania* lie elongate lobes of apparently collagenous material (shown in Fig. 3), and it is probably these which in *Mola mola* extend back between the widely spaced rays to form the lobes characteristic of the clavus of large specimens of that species.

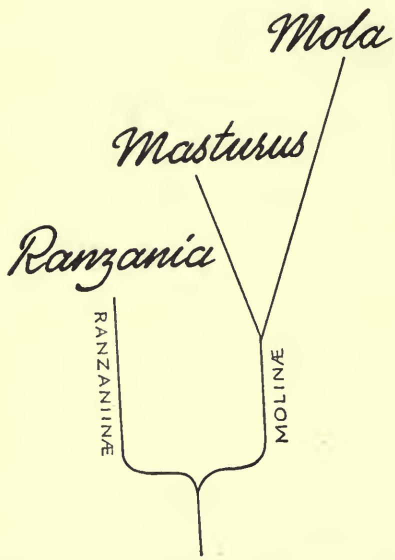

Fig. 2. Relationships of the genera of the family Molidae.

As a matter of interest, it may be remarked that *Ranzania*, *Mola*, and the Percomorphous family Carapidae (Fierasferidae) are the only fishes to which the term 'gephyrocercal' can properly be applied, as pointed out by Ryder when originally proposing the term.

Raven has taken the view that *Ranzania* is the most specialized of these genera. I cannot agree with this. Its skeleton is much less degenerate than that of *Mola*, more strongly ossified, and there are 18 or 19 vertebrae. The *lateralis* muscles are still moderately developed, though inserted posteriorly on the *m. dorsalis profundus*; the usual division of the dorsal portion into superior and inferior parts is still quite distinct anteriorly. I feel sure that Raven was mistaken in identifying the *lateralis* muscles as dorsal and anal depressors; they insert on to the latter but are distinct. The gill-rakers are free and apparently functional as in more generalized fishes. Further, this species is not gigantic.

It is not suggested, however, that *Ranzania* is completely representative of the ancestor of the other two genera; it has retained more primitive features, but it has completely lost the caudal fin, whereas *Masturus*, which is otherwise a stage farther towards *Mola*, retains a vestige of this fin, as will be shown later.

The relationships of these genera are therefore probably as shown in Fig. 2. An ancestral form in which the skeleton and musculature is still fairly normal and the caudal fin not completely lost gives rise to *Ranzania* on the one hand, which loses its caudal fin, and to *Masturus* on the other, in which the caudal fin retains a precarious hold but the skeleton and the musculature deteriorate. Further degeneration and complete loss of the caudal fin in this second line gives us *Mola*.

The need to recognize *Masturus* and *Mola* as more closely related to each other

than to *Ranzania* therefore still remains, and these two lines can now be expressed as subfamilies.

The three genera illustrate quite well the manner in which the *lateralis* muscles lose their primary function of flexing the body and become successively more closely associated with the dorsal and anal fins, their added power enabling these fins to

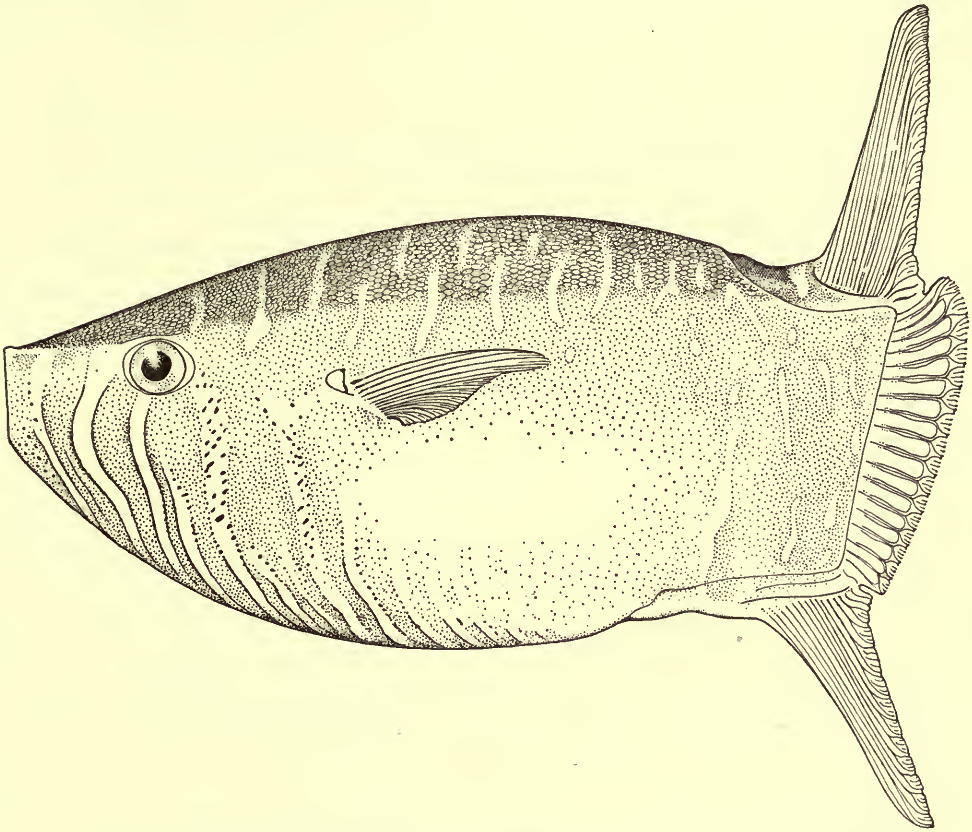

FIG. 3. *Ranzania laevis*, adult. A specimen 515 mm. long, from Baltimore, County Cork, Ireland.

become proportionately larger. The body is therefore held rigid, assisted in *Ranzania* by a carapace similar to that of *Strophiurichthys* among the Ostracionts, but with much smaller hexagonal plates; in *Masturus* and *Mola* this carapace is reduced to small denticles, and rigidity is assisted by a thick collagenous layer beneath the skin (Green, 1901).

All the species pass through a remarkable metamorphosis. The newly hatched larvae are *Tetraodon*-like, but soon (at 1–8 mm.) develop a cuirass of broad plates with jutting triangular projections, looking more reminiscent of an Ostraciont (Richardson named this stage *Ostracion boops*). With the atrophy of the larval tail, *Ranzania* seems to pass, by reduction of the cuirass and elongation of the body, into

a form essentially like that of the adult though proportionately longer, but *Masturus* and *Mola* show an intermediate stage, wherein the cuirass breaks up into small denticles and the triangular projections grow into long sharp spines on broad polygonal grooved bases (very like those of *Acanthostracion* or *Lactoria*). This stage is much shorter in the body than the adult. As growth proceeds the body lengthens and the spines shorten and disappear, though in *Mola* the bases of one on the snout and one at the chin are nearly always retained even in the largest specimens.

KEY TO THE GENERA OF MOLIDAE

I. Form comparatively elongate. Vertebrae 8+10 or 11. Carapace of smooth hexagonal plates,[1] terminating at bases of dorsal and anal fins and clavus. Lips produced forward beyond teeth as a funnel, closing as a vertical slit. Gill-rakers free. 2 uppermost branchiostegal rays coalesced. Clavus with 22 rays, all borne on interspinous bones. No secondary post-larval metamorphosis (subfamily RANZANIINAE) . . . . 1. *Ranzania*

II. Form shorter. Vertebrae 9+8. Carapace collagenous; skin of body and clavus with small rough denticles. Lips not funnel-like. Gill-rakers concealed in thick skin. 6 distinct branchiostegal rays. A secondary post-larval metamorphosis (subfamily MOLINAE).

A. Median rays of clavus not borne on interspinous bones, supporting a pronounced lobe; none of the rays bearing ossifications distally . . . . 2. *Masturus*

B. All rays in clavus borne on interspinous bones, most of them terminating in an ossification distally . . . . 3. *Mola*

Genus ***RANZANIA*** Nardo

? *Triurus* Lacepède, 1800, *Hist. Nat. Poiss.* **2**: 200. Type: *Triurus bougainvillianus* Lacepède.
Ranzania Nardo, 1840, *Ann. Sci. Regno Lombardo-Veneto*, **5**: 10, 105. Type: *Ranzania typus* Nardo (= *Ostracion laevis* Pennant).
Centaurus Kaup, 1855, *Arch. Naturgesch.* **21** (1): 221. Type: *Ostracion boops* Richardson (= *Ostracion laevis* Pennant, young).

The characters of this genus have been indicated concisely in the foregoing key.

Lacepède's description of *Triurus bougainvillianus* was based upon manuscript notes by Commerson. It could be interpreted as referring to the fish later known as *Ranzania*, but to describe the funnel-like lips as 'rictu fistulari' or 'le museau avancé en forme de tube' and again 'un museau très prolongé fait en forme de tube assez étroit' requires a good stretch of imagination. Moreover, the depth of the body is given as the proportion of 18 against the body-length of 71, and no other Sunfish has been recorded as slender as that. Finally, it has to be noted that in vol. 1 of the same work *Ranzania* is figured (pl. 22) under the name 'le Tetrodon lune'. The status of the name *Triurus* is therefore doubtful, and I hesitate to follow Whitley in using it, particularly since the name *Ranzania* is so well known.

A single species.

[1] In young specimens (90 mm.) each plate has a prominent bony tubercle centrally.

Ranzania laevis (Pennant)

Ostracion laevis Pennant, 1776, *Brit. Zool*, ed. 4, **3**: 129, pl. 19.

Tetrodon truncatus Retzius, 1785, *K. Svenska Vetensk Akad. Handl.* **6** (2): 121 (based on Pennant); Lacepède, 1798, *Hist. Nat. Poiss.* **1**: 514, pl. 22 f. 2; Donovan, 1808, *Nat. Hist. Brit. Fish.* **2**: pl. 41.

Orthragoriscus oblongus Bloch & Schneider, 1801, *Syst. Ichth.*: 511, pl. xcviii.

Orthagoriscus oblongus Jenyns, 1835, *Man. Brit. Vertebr. Anim.*: 491; Yarrell, 1836, *Hist. Brit. Fish.* **2**: 357, fig.; Couch, 1841, *Ann. Mag. Nat. Hist.* **6**: 144; Bonaparte, 1846, *Cat. Met. Pesci eur.*: 88; Bleeker, 1860, *Natuurk. Tijdschr. Ned.-Ind.* **21**: 57; Couch, 1865, *Hist. Fish. Brit. Is.* **4**: 381, pl. 246; Harting, 1868, *Verh. Akad. Wet. Amst.*: 12, pl. 2, fig. 2; Andrews, 1871, *Proc. Nat. Hist. Soc. Dublin*, **5**: 123; Sauvage, 1891, *Hist. Madagascar*, **16** (Poiss.): 529; Nobre, 1935, *Faun. Mar. Portugal, Vertebr.*: 242.

Cephalus oblongus Shaw, 1806, *Gen. Zool.* **5**: 439, pl. 176; Swainson, 1839, *Nat. Hist. Class. Fish.* **2**: 330.

Cephalus varius Shaw, 1806, ibid.

Orthragus commersoni Rafinesque, 1810, *Caratt. Sicilia*: 18.

Orthragus oblongus Rafinesque, 1810, *Indice Itt. Sicil.*: 40.

Tetraodon truncatus Couch, 1825, *Trans. Linn. Soc. Lond.* **14**: 88.

Cephalus elongatus Risso, 1826, *Eur. Mérid.* **3**: 173.

Mola planci Nardo, 1828, *Bull. Sci. Nat. Férussac*, **13**: 437.

Orthagoriscus truncatus Fleming, 1828, *Hist. Brit. Anim.*: 175; Günther, 1870, *Cat. Fish. Brit. Mus.* **8**: 319; Bleeker, 1873, *Ned. Tijdschr. Dierk.* **4**: 121; 1879, *Verh. Akad. Wed. Amst.* **18**: 26; Rochebrune, 1883–1885, *Faune Sénégambie* (*Poiss.*): 157; Day, 1884, *Fish. Gt. Brit.*: 276, pl. 149; Beauregard, 1893, *Bull. Soc. Sci. Nat. Ouest*, **3**: 229; Scharff, 1906, *Irish Nat.* **15**: 275; Mauro, 1906, *Boll. Accad. Gioenia, Catania*, N.S. **85**: 16, fig.

Cephalus cocherani Traill, 1832, *Mem. Werner*: **6**.

Orthragoriscus elegans Ranzani, 1839, *Novi Comment. Acad. Sci. Inst. Bonon.* **3**: table.

Orthragoriscus battarae Ranzani, 1839, ibid.

Ranzania typus Nardo, 1840, *Ann. Sci. Regno Lombardo-Veneto*, **5**: 105; Smith, 1949, *Sea Fish. S. Afr.*: 422, pl. 95, fig. 1212.

Ostracion boops Richardson, 1844, *Voy. Erebus and Terror, Fish.*: 52, pl. 30, figs. 18–21; Günther, 1880, *Intro. Study Fish.*: 175, fig. 93.

Orthagoriscus planci Bonaparte, 1846, *Cat. Met. pesci eur.*: 88; Canestrini, 1872, *Fauna d'Italia, Pesci*: 149; Stossich, 1879, *Boll. Soc. Adriat. Sci. Nat.* **5**: 36.

Orthragoriscus lunaris (Gronow) Gray, 1854, *Cat. Fish.*: 165.

Centaurus boops Kaup, 1855, *Arch. Naturgesch.* **21** (1): 221.

Ranzania truncata Jordan & Gilbert, 1883, *Bull. U.S. Nat. Mus.* **16**: 966; Trois, 1884, *Atti Ist. Veneto*, **2** (6) pt. 1: 1269, pls. 12–14; pt. 2: 1543, pl. 16; Perugia, 1897, *Ann. Mus. Stor. nat. Genova* (2), **18**: 140; Jordan & Evermann, 1898, *Bull. U.S. Nat. Mus.*: **47** (2): 1755; Steenstrup & Lütken, 1898, *K. danske vidensk. Selsk. Skr.* (6) **9**: 54, fig.; Günther, 1910, *J. Mus. Godeffroy*, **9** (17): 477; Pellegrin, 1912, *Bull. Soc. Zool. France*, **37**: 228, fig. 1; Ribeiro, 1915, *Arch. Mus. nac. Rio de J.* **17** (Molidae): 4, pl.; Thompson, 1918, *Mar. Biol. Rep. Cape Town* **4**: 176; Buen, 1919, *Bol. Pesc. Madr.* **4**: 295; 1935, *Notas Inst. esp. Oceanogr.* **2** (81): 146; Schmidt, 1921, *Nature, Lond.* **107**: 76, figs. 2, 4, 5; *Medd. Komm. Havundersøg. Fisk.* **6** (6), fig. 2. 13, pl. 1, fig. 7; Fowler, 1922, *Copeia* **112**: 84; Vinciguerra, 1923, *Comune di Genova* **3**: 5, fig. 3; Barnard, 1927, *Ann. S. Afr. Mus.* **21**: 989, fig. 32; Fowler, 1928, *Mem. Bishop Mus.* **10**: 475; Schmidt, 1932, *Dana's Togt omkr. Jord.*: 251, fig. 197 (6–11); Gudger, 1935, *Nature, Lond.* **135**: 548; Barnard, 1935, *Ann. S. Afr. Mus.* **30**: 655, fig. 6*c*; Ehrenbaum, 1936, *Handb. Seefisch. Nordeurop.* **2**: 88, fig. 69; Gudger, 1936, *Nature, Lond.* **137**: 947; Fowler, 1936, *Bull. Amer. Mus. Nat. Hist.* **70** (2): 1123, fig. 470; Ninni, 1939, *Atti. Soc. Ital. Sci. nat.* **78**: 236; Raven, 1939, *Amer. Mus. Novit.* **1038**, figs. 1–3; Clark, 1949, ibid. **1397**: 7, fig. 9; Maul, 1949, *Vertebr. Madeira* **2** (Peixes): 158.

Ranzania makua Jenkins, 1895, *Proc. Calif. Acad. Sci.* (2) **5**: 780, pl.; Fowler, 1900, *Proc. Acad.*

Nat. Sci. Philad.: 514; Jordan & Snyder, 1901, *Proc. U.S. Nat. Mus.* **24**: 262; Jenkins, 1902, *Bull. U.S. Fish. Comm.* **22**: 486 (1903); Jordan & Evermann, 1905, *Bull. U.S. Fish. Comm.* **23** (1): 439, fig. 194; Jordan, Tanaka, & Snyder, 1913, *J. Coll. Sci. Tokyo* **33**: 231, fig. 166; Snyder, 1913, *Proc. U.S. Nat. Mus.* **44**: 460, pl. 63; Tanaka, 1914, *Fig. Descr. Fish. Japan* **16**: 274, pl. 76; Jordan & Jordan, 1922, *Mem. Carneg. Mus.* **10** (1): 89; Jordan, Evermann, & Tanaka, 1927, *Proc. Calif. Acad. Sci.* **16** (4): 680.

Orthagoriscus (larva) Sanzo, 1919, *Mem. R. Com. Talassogr. ital.* **69**: 1–7, figs. 1–4.

Ranzania laevis Whitley, 1933, *Vict. Nat.* **49**: 211, figs. 6, 7; Phillips, 1941, *Trans. Proc. Roy. Soc. N.Z.* **71** (3): 245, pl. 41, fig. 6; Deraniyagala, 1944, *J. Bombay Nat. Hist. Soc.* **44** (3): 429.

Triurus laevis Whitley, 1937, *Mem. Queensland Mus.* **11** (2): 147; Hale, 1944, *S. Aust. Nat.* **22**: pt. 4, pl. 1, figs.

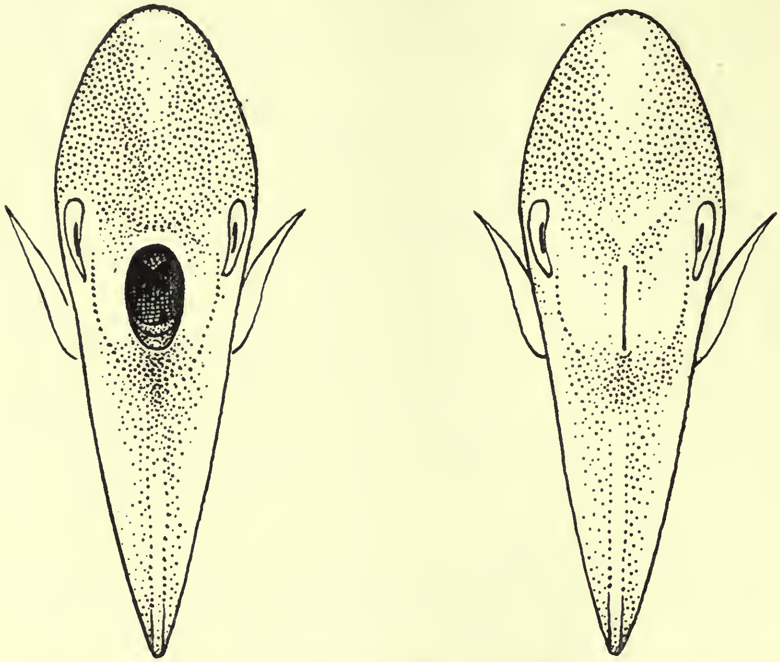

FIG. 4. *Ranzania laevis.* Front view of head, showing mouth open and closed.

Examination of the records leaves little doubt that a single species of *Ranzania* ranges the seas of the whole world except the polar regions, but it seems that two subspecies can be recognized as follows:

Ranzania laevis laevis (Pennant). Depth of carapace contained twice or more in its length, in adults (up to 580 mm.). Axil of pectoral fin well below level of centre of eye. Height of anal fin less than $\frac{3}{5}$ length of head. Atlantic Ocean.

R. l. makua Jenkins. Depth of carapace contained less than twice in its length, in adults (400–500 mm.). Axil of pectoral fin above level of centre of eye. Height of anal fin $\frac{2}{3}$ length of head or more. North Pacific Ocean.

That these two forms are simply subspecific extremes in the range is shown by the records from the Indian Ocean, wherein the depth is usually given as for *makua* while

the pectoral fin is low as in *laevis*. A specimen from Mauritius in our collection shows these features well, and a closely similar specimen has been figured by Whitley from Australia.

Whenever the coloration has been described it has been shown to be closely similar in all these forms, a pattern of pale transverse bands on a darker ground, the bands edged with spots and broken lines of black; three bands associated with the eye are

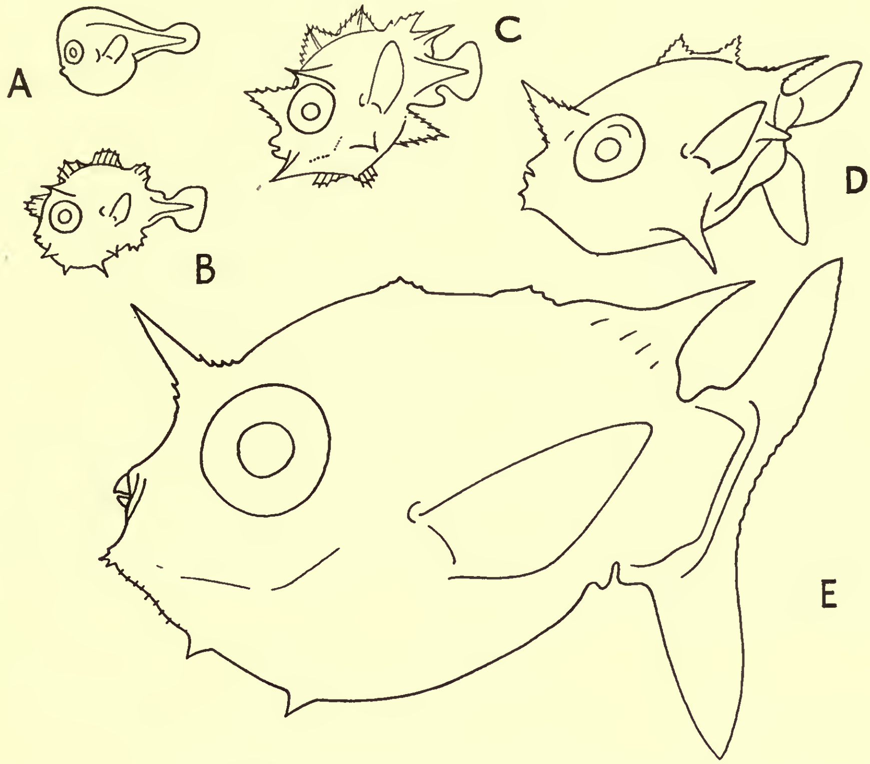

FIG. 5. Development of *Ranzania laevis*.
A, larva (1·7 mm.); B, C, D, early, full, and late '*Ostracion boops*' stage; E, transition to adult form (8 mm.). (After Schmidt.)

the most constant, the posterior ones being variously broken or anastomosed, sometimes enclosing large oval areas of the ground colour. The colours are said to be very brilliant in life.

The mouth is very curious, the lips extending well beyond the teeth and forming a funnel, the mouth being oval with the long axis vertical. The orifice closes along this axis, so that the rictus is really vertical—apparently unique among fishes (Fig. 4). This feature was shown clearly in the earliest published picture of the fish (Aldrovandi, 1613), a remarkably good representation for its period.

Too little is known of the feeding habits to show whether they can be associated with the peculiar mouth, but the species has been reported to take littoral algae

(Barnard, 1927), and it is possible that the lips can suck in and close upon a frond while the teeth nip it off.

The fine developmental series given by Schmidt (1932) shows that Raven was correct in supposing that elongation of the body is secondary, but it also shows that *Ranzania* is never so greatly shortened as the other two genera (Fig. 5). Lengthening occurs after the 8-mm. stage, until at 53 mm. the length of the carapace is about 3 times its depth. This proportion is maintained up to 90-mm. size, and after that the depth of the body increases with growth, so that at 250 mm. the length of the carapace is 2·5 times its depth, at 430 mm. 2·25 times, at 515 mm. 2·1 times, and at 580 mm. only twice. These figures are for the Atlantic form as shown by our specimens; in the North Pacific subspecies *R. makua* either the early lengthening is not so great or the later deepening is more rapid.

The general use of the name *truncatus* for this species seems to date from Günther, 1870; it is not clear why he chose this name rather than that of Pennant, on whose work that of Retzius was based, but possibly it was due to the fact that Pennant's description was numbered 54, while on his plate the number 54 appears beside a figure of the 'Short Diodon' (*Mola mola*), leaving the other Sunfish without a number. As both description and figure are titled 'Oblong Diodon', however, this is clearly an error in numbering, and there can be no doubt as to the identity of *Ostracion laevis*, which antedates *Tetrodon truncatus* by nine years.

Ranzania laevis does not reach so enormous a size as the other members of the family, apparently not exceeding 800 mm. in length. It has been recorded from all warm seas, as far north as Scandinavia and far south as New Zealand, usually from single specimens—though it was once observed in great numbers at the surface of the water off Martinique (Pellegrin, 1912). As Schmidt has pointed out, most records of larval Sunfishes to date belong to this species, and he has given us a fairly complete picture of its development from egg to adult.

Genus ***MASTURUS*** Gill

Masturus Gill, 1884, *Proc. U.S. Nat. Mus.* **7**: 425. Type: *Orthagoriscus oxyuropterus* Bleeker.

The study of this genus has been greatly facilitated by the careful bibliographical work of Gudger, who studied the records over a number of years, added several new ones, and finally in 1937 published a work dealing with the structure of the caudal region and another summarizing the knowledge of the genus up to that date. The latter two works are of great value, and the remarks which I make in the pages which follow are based largely upon them and should be considered with constant reference to them.

The distinctness of *Masturus* from *Mola* had already been acknowledged by Steenstrup & Lütken (1898), and discrimination between the post-larval forms was achieved by Schmidt (1921). The secondary post-larval stage of *Masturus* is characterized by enormous elongation of the 'cornicles' (Fig. 6). But it remained for Gudger to disentangle the confusion in the literature, and it is no doubt because these necessitated a chronological arrangement of his data that he was unable to recognize the two forms involved. But an analysis of the records leaves little room for doubt that there

are indeed two forms, one the generally accepted *M. lanceolatus* (Liénard), the other apparently taking *M. oxyuropterus* (Bleeker) as the earliest name. These will be diagnosed on a later page, but it is necessary to note their existence at this point in order to clarify the discussion which follows. I must stress now, however, that they are regarded here as species only because we have no knowledge to the contrary, but I suspect that they may prove to be the sexes of one species. Not one of the

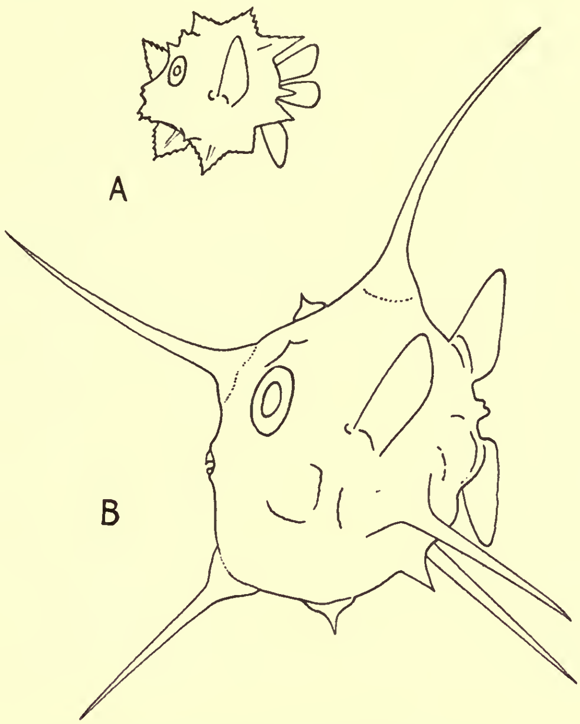

FIG. 6. Post-larvae of *Masturus*.
A, '*Ostracion boops*' stage (2·8 mm.); B, '*Molacanthus*' stage (5 mm.). (After Schmidt.)

specimens so far recorded has been sexed. Raven, the only person to make a dissection, does not even mention the gonads.

Masturus is peculiar among the Molidae in the possession of a pronounced lobe a little above the centre of the clavus. Gudger continually stressed the dorsal situation of this lobe, apparently as evidence that it could not be the remains of the larval tail; this is not a very good point, for his own anatomical figures show that the lobe is associated with the end of the vertebral column. In other Plectognathi the vertebral column lies dorsally until it enters the caudal peduncle, where it lies approximately in the central long axis of the body. The fact that in the Molidae the vertebral column is dorsally placed at its hind end is therefore interesting as a further demonstration that the posterior part of the column is lost.

It is my belief that the lobe on the clavus of *Masturus* can truly be called the

'caudal lobe', for all the illustrations of its anatomy so far given seem to demonstrate that the slender rays supporting it are caudal rays. The first to be published was that by Ryder, after a drawing by Putnam; it was reproduced by Gudger, and is now copied as my Fig. 7 A. It is interesting in that the dorsal and anal rays of the clavus are shown branched, a feature shown only once elsewhere in the literature (Gudger, 1939), perhaps because the tips are so often broken off in young specimens. They are

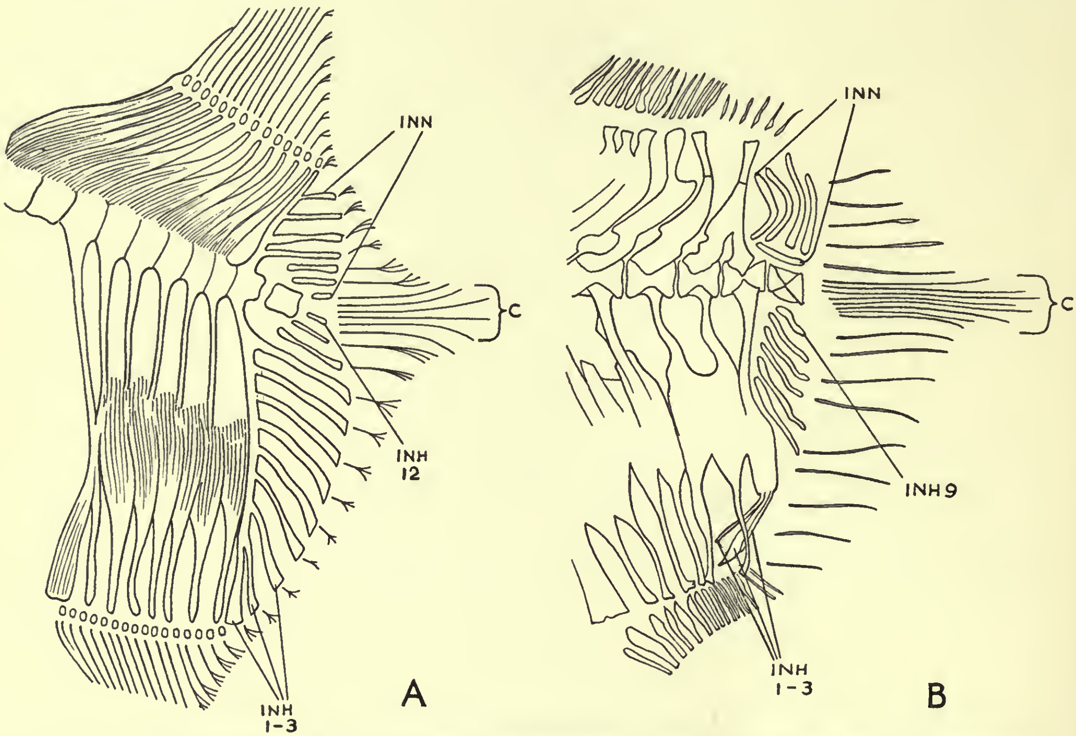

Fig. 7. Caudal skeletons of A, *Masturus oxyuropterus*, copied from Ryder, 1886; B, *Masturus lanceolatus*, copied from Gudger, 1937.
c, caudal rays; INN, interneural bones; INH, interhaemal bones.

thus distinguishable at a glance from the simple caudal rays in the middle, but it is probable that the outermost two of the latter are also of dorsal and anal origin, for they have each a small skeletal support.

The interspinous bones supporting the clavus are shown completely fused with the hindmost remaining haemal spine. Comparison with other dissections shows that these must in fact have been distinct elements. The shape of the supporting bones of the dorsal and anal fin lobes is obscured by the inclinator muscles in this figure, but the drawing of these muscles is interesting in helping to show their character after the *lateralis* mass has been removed.

Each of the rays in the clavus is supported by an interspinous bone, with the exception of the middle four; these are associated with the last of the remaining vertebrae,

which has no neural or haemal elements. There is no apparent reason why, if they also are dorsal and anal rays, they should not have their supports; but if they are caudal rays they cannot be expected to be borne on hypurals, since these and other posterior vertebral elements have been lost. The presence of only four of these unsupported rays and the equal length of the dorsal and anal fin bases shows that Putnam's fish was a *Masturus oxyuropterus*; two other dissections of this form have been illustrated—that by Gudger (1937 *a*, p. 41, fig. 27), and that by Raven (1939 *b*). The first does not show the internal skeleton, and one of the caudal rays is doubled, as can be seen by the nature of its basal cartilage; but Raven's illustration, drawn by Helen Ziska, is admirable, and agrees in all essentials with that by Putnam. The only illustration showing the anatomy of *M. lanceolatus* is that given by Gudger in the work just quoted, based upon a young specimen (the same size as Putnam's) which was stained with alizarin and cleared. During the staining process some of the elements, notably the interneural supports of the clavus, were displaced, but I am satisfied that nothing was lost. This illustration is copied here as my Fig. 7 B. Here it will be seen that the central lobe of the clavus is supported by eight rays whose only skeletal support is the last vertebra (which has no neural or haemal elements). Above these are five rays which can be associated with the five interneural bones which have been displaced from the horizontal during preparation. Below them are nine rays which belong to nine interhaemals, the lower three of which have been displaced forward. The presence of eight rays in the caudal lobe of the clavus and the greater length of the base of the dorsal fin lobe as compared with that of the anal fin lobe shows this to have been a specimen of *Masturus lanceolatus* as identified by Klunzinger (a figure of whose specimen is given by Gudger).

It is admittedly hazardous to speak of caudal rays when the hypural bones are lost, since in normal fishes caudal rays are distinguishable only by their association with the hypurals. But I feel convinced that these central rays of the clavus in *Masturus* are homologous with the hypocaudal rays of the more generalized forms, and it remains for me to suggest how it is possible for them to persist although their skeletal supports are lost.

It has to be borne in mind that two opposing forces are involved during the development of the caudal region, interacting in different proportion at successive stages. First there is the reduction of the larval tail and the atrophy of the posterior vertebral elements, and secondly the normal growth of body and fins.

The first process evidently begins at an early age, for Schmidt has figured a larval specimen in which, as Gudger has pointed out, dorsal and anal rays are present but not caudal rays; development of the latter is retarded. To see how this fact may affect later stages it is necessary to consider what occurs in the Triacanthodidae, the most primitive family of Plectognathi. In the larval Triacanthodid (Fig. 8), the caudal rays are twelve in number, as in most Plectognathi, but the last four lie in relation to the end of the notochord, which will later become ossified as the urostyle; the anterior eight belong to the last few myotomes. Degeneration of the tail from the rear will mean that the end of the notochord is lost first, and if this occurs before the hypocaudal rays appear not more than eight of them will develop. The eight slender rays of *Masturus lanceolatus* thus become intelligible and significant, while the

presence of only four in *M. oxyuropterus* suggests that reduction has proceeded still farther before caudal rays begin to develop in this form. Comparison with the larval *Mola* figured by Sanzo (1939) is interesting in this connexion, for it will be seen that if in his specimen hypocaudal rays were developed, they would not be associated with myotomes, and this probably accounts for their absence in that genus.

As the caudal rays become stronger the axial structures decrease rapidly, so that by the time the rays are brought to the homocercal position there are no hypurals for their support, nor neural or haemal elements for the last few vertebrae; but normal

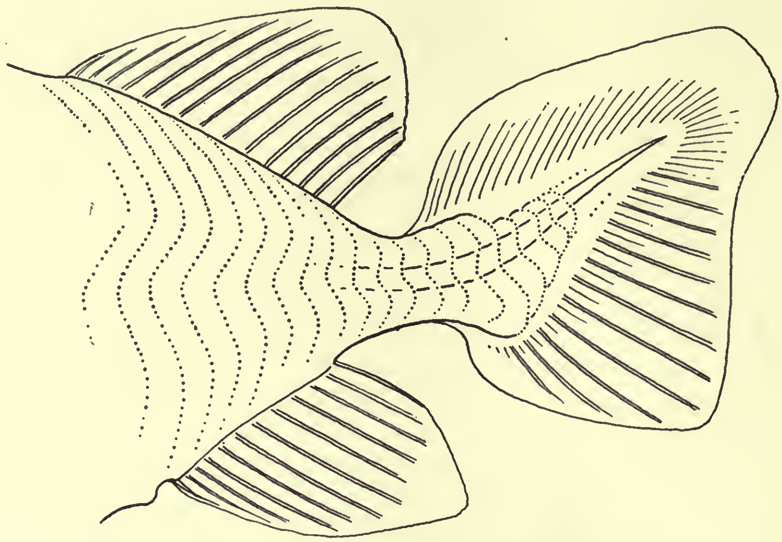

Fig. 8. Caudal region of post-larval Triacanthodid fish, showing relationship of hypocaudal rays to notochord and myotomes.

body growth has extended the posterior parts of the dorsal and anal fins with their supporting structures backward and downward to fill the void. This process is probably correctly demonstrated by Ryder's diagram, upon which mine is based (Fig. 1), in which the region of atrophy is delineated by the broken line. The vertebrae with their neural and haemal arches and spines are lost, but the interneural and interhaemal spines develop in relation to the fins in the normal manner except that they ultimately become tilted nearly at right angles to the last developed vertebral elements (Fig. 7). The number of these interspinous bones does not give a reliable estimate of the number of vertebrae that have been lost, because reference to the dissections shows that more than one may be associated with each neural or haemal spine, while of course the last few vertebrae are probably not associated with interspinous bones at all. Ryder, of course, thought Putnam's young fish was a *Mola* and that the caudal rays were completely lost in the adult. A curious feature of the posterior migration of the dorsal and anal fins is that, while in the lobes the rays are more numerous than the interspinous bones, each of those in the clavus has its own supporting element; this might be taken to indicate that the central rays, which I

regard as caudal, are simply the last dorsal and anal rays, which are therefore more numerous than their supports in this region also, but there seems no good reason why the odd rays should all be crowded at the end. A more difficult argument to combat is that the supporting elements of these last rays cannot develop because of the presence of the vertebral column; against this I can only point out that in Putnam's fish two elements lie *behind* the last vertebra, and there seems no reason why, if the odd four rays were in the same series, their supporting bones should not be there also. In fact, the presence of the two elements mentioned is reminiscent of the condition

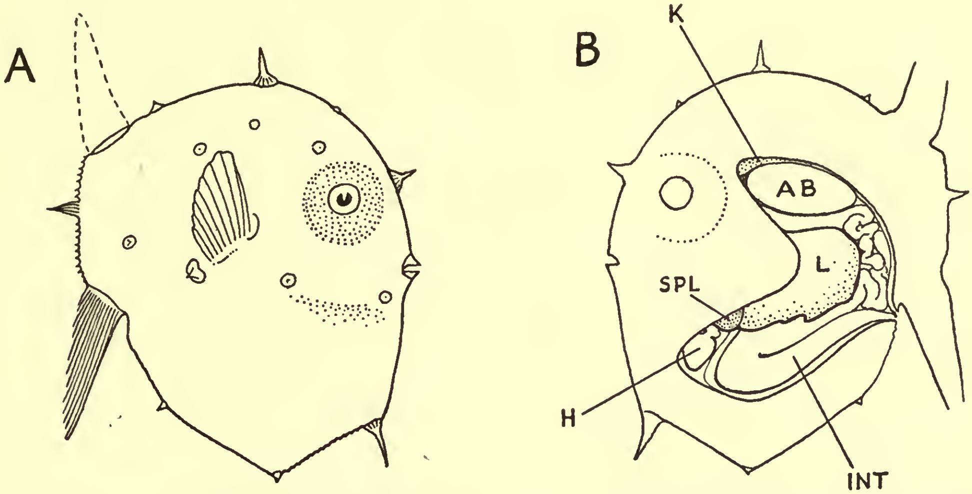

FIG. 9. *Masturus oxyuropterus*, late post-larva (21 mm.), in British Museum collection. B, dissection of same specimen, showing presence of air-bladder.
AB, air-bladder; H, heart; K, kidney; L, liver; INT, intestine; SPL, spleen.

shown in *Cyema atrum* by Trewavas (1933), who identified the two small ossifications as hypurals. But since the last caudal vertebrae are so obviously lost in the Molidae it would be incautious to speak of hypurals here.

McCulloch has left us drawings of very young examples of both *M. lanceolatus* and *M. oxyuropterus*, at the stage when the larval tail is not quite lost, the small peduncle bearing its allotted quota of caudal rays and the dorsal and anal fins extending round to meet them. Knowing what a careful observer and excellent draughtsman McCulloch was, I am prepared to accept these as good evidence. Eventually, at the better known stage of 50 mm. or thereabouts, there is no sign of the original tail, but the caudal rays project beyond the rest of the clavus as the basis for the ultimate central lobe. Gudger believed that even these central rays were lost, at what he called the 'square-tailed' stage, but as this was based on the two obviously damaged specimens of Steenstrup & Lütken, this seems to be improbable—a point which Dr. Gudger himself has conceded in a letter to me.

As a matter of interest I may mention here that in these small specimens it appears that the air-bladder is still present; one which I dissected (Fig. 9 B) had a very

delicate, bubble-like structure at the centre of mass, which unfortunately collapsed while I was examining it. At this planktonic stage in its development such an organ is not surprising, and of course the Molidae are evolved from fishes in which the air-bladder is well developed, but it is worth noting that the statement that an air-vessel is absent in this family is probably true only of adults.

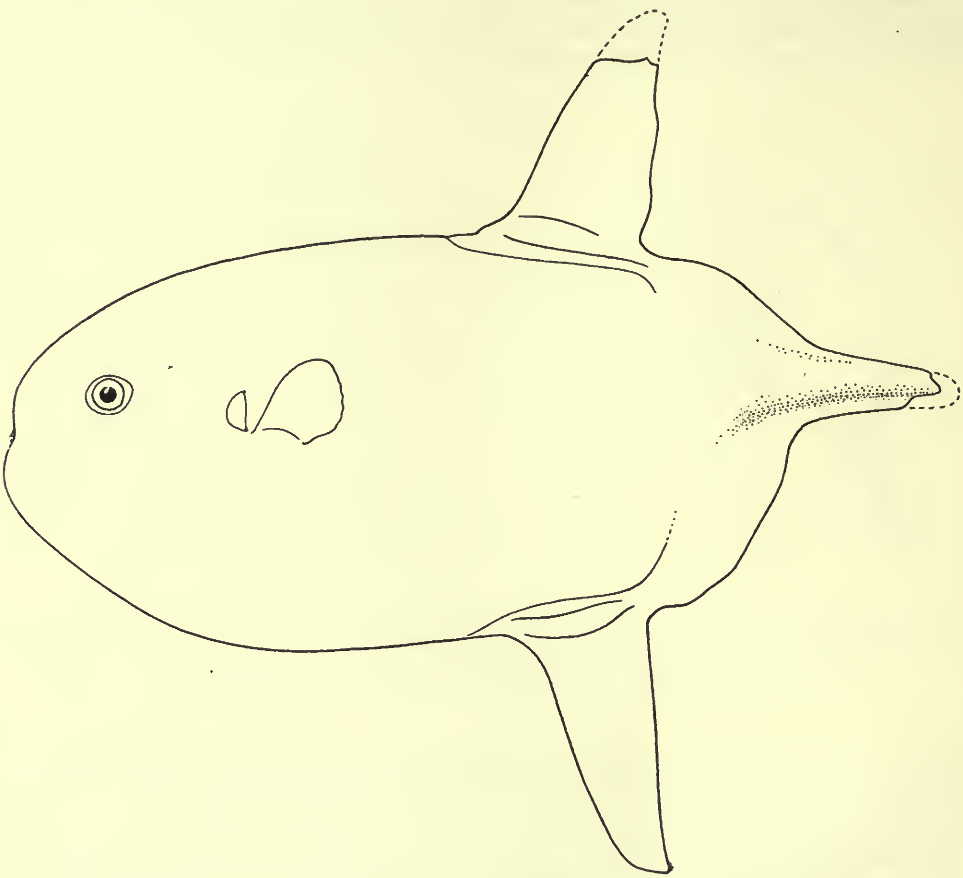

Fig. 10. *Masturus lanceolatus*, adult. Singapore. (After Smedley, 1932.)

With the development of the skeletal structures (poorly ossified though they are) atrophy proceeds no farther, and the processes of growth produce what later changes we can observe in the fish. An extension of the dermis and its collagenous substratum, probably that which would develop over the caudal peduncle in a more normal fish, eventually covers the caudal lobe and the whole clavus.

These are what seem to be the main features in the development of the clavus of *Masturus*, but there is a certain amount of individual variation. In *M. lanceolatus* the presence of eight caudal rays seems to be fairly consistent, but the middle ones are sometimes represented only distally—whether their proximal ends atrophy in the early stages or degenerate later is not evident. In *M. oxyuropterus* four caudal rays

are usual, but may occasionally be five (as in a dissection figured by Gudger, wherein one of the rays had split or doubled as shown by its supporting cartilage) or rarely three. On published evidence the number of rays supporting dorsal fin, clavus, and anal fin respectively appear to differ very greatly, but most of these are of doubtful value, for an accurate count can only be made by dissection (except possibly in stuffed specimens). As an example of this may be quoted the description by Gudger, a careful worker, of the specimen he obtained for the American Museum of Natural History. In this he counted, on external examination, 'D.+C.+A. complex = 60'; the fish is in other respects *M. oxyuropterus*, so that this high count would cast doubt on its distinctness from *M. lanceolatus*. But later Raven dissected this same fish, and his illustration shows distinctly the total of fifty-five rays which is usual in *M. oxyuropterus*. Consequently it has not seemed expedient to give any definite statement of the number of rays to be found in dorsal and anal fins and clavus respectively, but only to indicate the total number, which seems to be characteristic for each species.

Whether or not I am correct in calling them caudal rays, the presence of median rays unsupported by interspinous bones is characteristic of *Masturus*. In the adults all the rays of the clavus are simple, without distal ossifications. There is always a median projection to the clavus, and the body is rather more elongate than that of *Mola*, especially in the early stages. Osseous tubercles, the remains of post-larval spines, seem never to be retained anywhere on the body of the adult.

Two forms can be recognized, treated here as species, but I suspect that further study will show them to be the sexes of one. They have been taken in the same localities, and sometimes together. The sexual dimorphism found to be present in *Mola mola* (p. 117) lends support to this idea. But with no knowledge of the sex of any recorded individual I can but state their characteristics and apply available names to them pending further information.

Since all the literature before 1939 has been fully quoted and discussed by Gudger, I have not thought it necessary to repeat it all below, particularly as a number of records cannot be assigned with certainty, but full and discriminating reference has been made to Gudger's papers.

KEY TO THE SPECIES OF *MASTURUS*

I. Profile of lower jaw more convex, usually projecting beyond the upper. Upper profile of head evenly convex. Base of dorsal lobe conspicuously longer than that of anal fin. Dorsal and anal fins and clavus with a total of 60 to 62 rays. Caudal lobe of clavus[1] longer than head in perfect specimens (often mutilated), supported by eight (rarely 7 or 9) rays . . . . . . 1. *lanceolatus*

II. Profile of lower jaw less convex, straight or concave, not projecting beyond the upper. Upper profile of head with distinct concavity above the eyes. Bases of dorsal and anal fin lobes about equal. Dorsal and anal fins and clavus with a total of 55 to 57 rays. Caudal lobe of clavus shorter than head, supported by 4 (rarely 3 or 5) rays . . . . 2. *oxyuropterus*

The uncertainty of authors as to where dorsal and anal fins end and clavus begins,

[1] Measured from 'hinge' of clavus to tip.

and the obvious inaccuracy (already mentioned) of fin-ray counts made upon external examination, militates against giving counts for individual fins, but it may be, as suggested by Gudger's cleared specimen, that in *M. lanceolatus* there are more

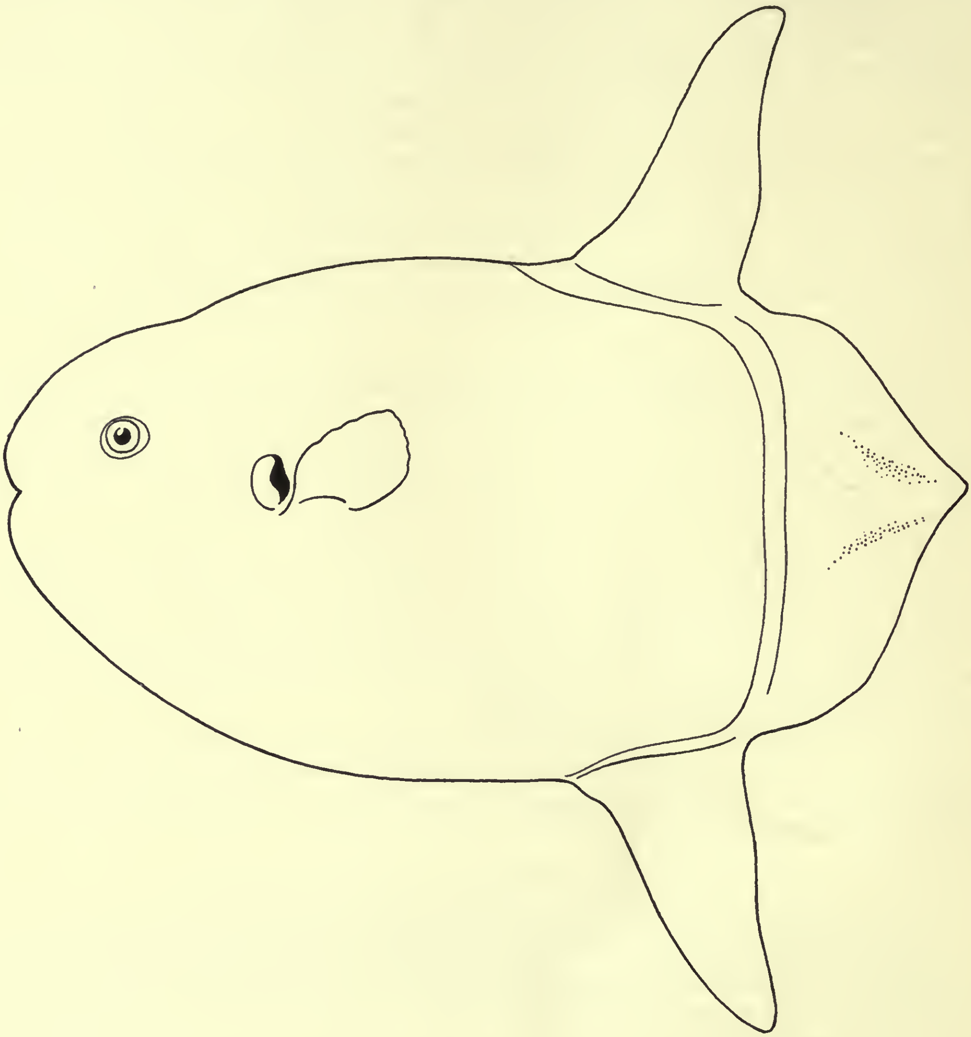

FIG. 11. *Masturus oxyuropterus*, adult. Tahiti. (After Gudger, 1935.)

rays in the dorsal lobe than in *M. oxyuropterus*. In the latter, on the other hand, the number of claval rays supported on interhaemal bones seems to be greater (10 to 12) than in *M. lanceolatus* (9).

Although usually these types seem to be recognizable at an early age, there are some doubtful cases among young specimens, as might be expected if they were the

sexes of one species. For example, if *M. lanceolatus* should be the male, it might be more like the female (*M. oxyuropterus*) when young, as in many other fishes, and in fact small examples of the *oxyuropterus* type seem to be the more common.

Masturus lanceolatus (Liénard)

Orthagoriscus lanceolatus Liénard, 1840, *Revue Zool.*: 291; 1841, *Magasin Zool.* (2) **3** (Poiss.): pl. 4.

Orthagoriscus mola Klunzinger, 1871, *Verh. Zool.-Bot. Ges. Wien*, **21**: 648; Günther, 1880, *Introd. Stud. Fish.*: 175, fig. 94; Perugia, 1881, *Ann. Mus. Stor. Nat. Genova* **27**: 365, fig.

Mola mola Collett, 1896, *Résult. Camp. Sci. Monaco* **10**: 163, pl. 6, fig. 1.

Ranzania truncata Steenstrup & Lütken, 1898, *K. danske vidensk. Selsk. Skr.* (6) **9**: pl. 6, fig. C. (Not of Jordan & Gilbert, 1883.)

Mola (*Molacanthus*) sp. McCulloch, 1912, *Proc. Linn. Soc. N.S.W.* **37** (3): 553, pl. 58.

Mola lanceolata Schmidt, 1921, *Medd. Komm. Havundersøg. Kbh., Fisk.* **6** (6): pl. 1, figs. 4, 5; 1932, *Dana's Togt omkr. Jord.*: 255, fig. 167 (*part.*); Barnard, 1927, *Ann. S. Afr. Mus.* **21**: 987, fig. 31; Ehrenbaum, 1936, *Handb. Seefisch. Nordeurop.* **2**: 88; J. L. B. Smith, *Sea Fish. S. Afr.*: 422, fig. 1214.

Masturus lanceolatus Hubbs & Giovannoli, 1931, *Copeia*, **1931**: 135; Gudger, 1935, *Amer. Mus. Novit.* **778**: 1, fig. 1; Gudger & McDonald, 1935, *Sci. Mon.* **41**: 1, figs. 4–9, 11, 14, 15; Rivero, 1936, *Amer. Nat.* **70**: 92, fig.; Palmer, 1936, *Science*, **83**: 597; Gudger, 1937, *Ann. Mag. Nat. Hist.* (10) **19**: 9, fig. 6; 15, fig. 10; 31, fig. 19; 33, fig. 20; 34, fig. 21; 38, fig. 23; *Proc. Zool. Soc. Lond.* **107** (A) (3): 353 (*part.*), text-figs. 1, 2, 4, 6, 7, 8, 9, 14 (?), 16, 20, 21 (?); pl. 1, figs. 3, 4; pl. 2, figs. 5, 6; pl. 4, fig. 10; 1939, *J. Elisha Mitchell Sci. Soc.* **55** (2): 305; Brimley, 1939, ibid. 295, pl. 28; Fitch, 1950, *Calif. Fish Game*, **36** (2): 65.

Liénard's figure cannot be said to be notable for its faithful representation, but as it shows the caudal lobe indubitably much longer than the head and the base of the dorsal fin longer than that of the anal, it shows to which of our two forms the name is applicable. The fin-rays are always more easily seen in dried specimens of these fishes, and so Klunzinger's stuffed example shows the structure of the clavus very well; it is closely similar (in this 65-in. example) to that of Gudger's 53-mm. cleared specimen. Other figures in Gudger's papers which appear to represent this form are stated in the above synonymy. Where the caudal lobe is mutilated or otherwise doubtful the broad dorsal base and rather pugnacious-looking 'chin' are the most useful distinguishing characters.

It grows to a great size, the largest recorded specimen being 10 ft. long and 11 ft. 3 in. from the tip of dorsal to tip of anal fins. In our collection it is represented only by the post-larval specimen figured by Günther.

Recognizable records of adults are from the Atlantic, off Florida, Havana, North Carolina, and Table Bay, South Africa, from the Red Sea, and from the Pacific at Tahiti. Young specimens have been taken off Alabama, Teneriffe, and in the South Seas. As this paper goes to press Fitch (1950) states that 100 post-larvae $\frac{1}{4}$ to 2 in. in length have been taken from the stomachs of tuna in Hawaiian waters.

Masturus oxyuropterus (Bleeker)

Orthagoriscus spinosus Gatchet, 1832, *Act. Soc. Linn. Bordeaux* **5**: 253. (Not of Cuvier, 1817.)

Orthagoriscus oxyuropterus Bleeker, 1873, *Versl. Akad. Amst.* (2) **7**: 151, fig.

Mola rotunda Ryder, 1886, *Rep. U.S. Fish. Comm.* (1884): 1027, pl. 8, fig. 5. (Not of Cuvier, 1798.)
Ranzania truncata Steenstrup & Lütken, 1898, *K. danske vidensk. Selsk. Skr.* (6) **9** (1): 98, pl. 6, figs. D, E. (Not of Jordan & Gilbert, 1883.)
Mola (*Molacanthus*) *sp.* McCulloch, 1912, *Proc. Linn. Soc. N.S.W.* **38** (3): 553 (*part.*), pl. 59.

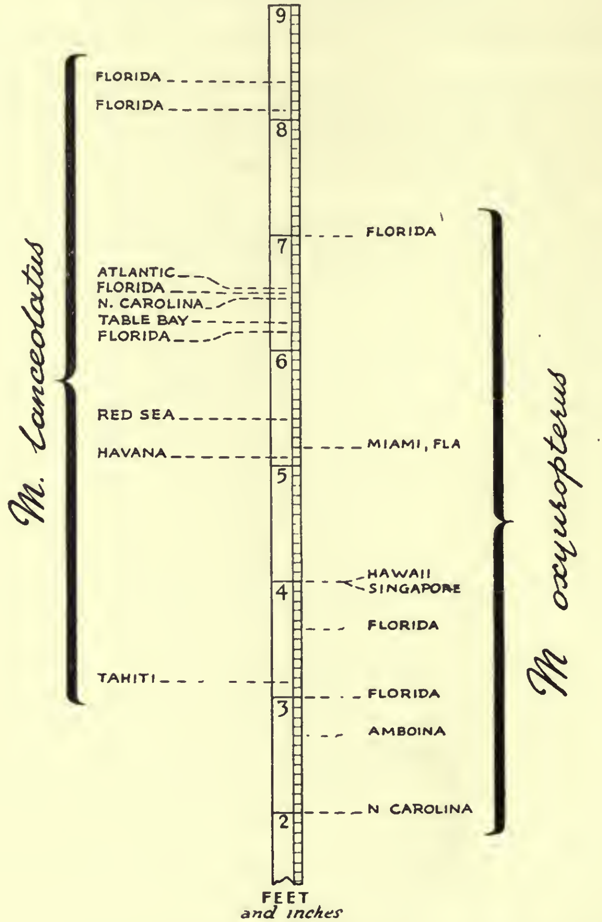

FIG. 12. Diagram showing comparative ranges of size for the two species of *Masturus*, based on recognizable records of adult specimens.

Mola mola Townsend 1918, *Bull. N.Y. Zool. Soc.* **21:** fig. (not of Linnaeus); Collett, 1896, *Résult. Camp. Sci. Monaco*, **10:** 163 (*part.*) pl. 6, fig. 1.
Mola lanceolata Schmidt, 1921, *Medd. Komm. Havundersøg. Kbh. Fisk.* **6** (6) (*part.*): pl. 1, fig. 6; Smedley, 1932, *Bull. Raffles Mus.* **7:** 17, pl.
Masturus lanceolatus Jordan & Jordan, 1925, *Mem. Carneg. Mus.* **10:** 89, fig. 7; Gudger & McDonald, 1935, *Sci. Mon.* **41:** 1, figs. 3, 10, 12, 13; Gudger, 1935, *Copeia*, **1935:** 35, figs. 1, 2; 1937, *Ann. Mag. Nat. Hist.* (10) **19:** 1 (*part.*), text-figs. 18, 22, 26, 27; 1937, *Proc. Zool. Soc. Lond.* **107** (A) (3): 353 (*part.*), text-figs. 5, 10, 12, 13, 15, 18 (?), 19, 22, pl. 1, figs. 1, 2, pl. 3, fig. 9 (?), pl. 4, fig. 11, pl. 5, fig. 17; 1939, *J. Elisha Mitchell Sci. Soc.* **15** (2): 305 (*part.*), figs.

1–5; Brimley, 1939, ibid. 300, pl. 29; Raven, 1939, *Bull. Amer. Mus. Nat. Hist.* **76** (4): 143, pl. 2; Hardenberg, 1939, *Treubia* **17** (2): 121; Clark, 1949, *Amer. Mus. Novit.* **1397**: 7, fig. 9.

A high proportion of the young specimens recorded seem to belong to this form, but a possible explanation of this is given on page 107. The small number of supporting rays in the caudal lobe, the equal bases of dorsal and anal fins, and the comparatively weak-looking 'chin' are recognizable even in McCulloch's 10-mm. specimen. The concavity of the dorsal profile of the head, however, is not noticeable in very small specimens, but it is already apparent in the 152-mm. example figured by Gudger (1939). The latter paper is also interesting in that it shows branching at the tips of the rays of the clavus, like that illustrated by Ryder (Fig. 7 A in this paper), but very much smaller, evidently in process of reduction. Only these two records of such branching exist, probably because the tips of the rays have been damaged in most small specimens, and the branching is lost with age.

This form is so often taken in the same locality as the preceding that it is almost certainly a sex of that species; in some instances young specimens of both forms have been taken from a single predatory fish (e.g. McCulloch (1912), whose 13-mm. specimen is *M. lanceolatus* and his 10-mm. specimen *M. oxyuropterus*; or Gudger (1939), whose 125-mm. fish is *M. oxyuropterus*, whereas at least the 127-mm. fish, and possibly the 130-mm. specimen also appears to be *M. lanceolatus*).

It will be noticed that in each case the *M. oxyuropterus* is slightly the smaller, and the records of this form do tend to lie about a lower range of size (Fig. 12). The largest record seems to be the 'Miami *Masturus* no. III' of Gudger, figured by Gudger & McDonald, though the identification of this badly slung specimen is a little doubtful. It was 7 ft. in length.

Recognizable records of adults of this form are from the Atlantic at North Carolina and Florida, from Singapore and Amboina, and from the Pacific at Hawaii. Young specimens have been taken at Florida, the Sargasso Sea, the Azores, and in the South Pacific.

A young specimen (Fig. 9) of unknown provenance is in our collection, and a plaster cast of the specimen dissected by Raven is exhibited in the fish gallery of the British Museum (Natural History).

Genus *MOLA* Koelreuter

Mola Koelreuter, 1770, *Novi Comment. Acad. Petropol.* **8**: 337. Type: *Mola aculeata* Koelreuter (= *Tetraodon mola* Linnaeus, young).

Orthragoriscus Bloch & Schneider, 1801, *Syst. Ichth.*: 510. Type: *Tetraodon mola* Linnaeus.

Cephalus Shaw, 1804, *Gen. Zool.* **5**: 437. Type: *Tetraodon mola* Linnaeus.

Orthragus Rafinesque, 1810, *Caratt. Sicilia*: 17. Type: *Orthragus luna* Rafinesque (= *Tetraodon mola* Linnaeus).

Diplanchias Rafinesque, 1810, ibid. Type: *Diplanchias nasus* Rafinesque.

Orthagoriscus Cuvier, 1817, *Règne Anim.*, ed. 1, **2**: 149. Type: *Tetraodon mola* Linnaeus.

Pedalion Swainson, 1839, *Nat. Hist. Fish.* **1**: 199. Type: *Pedalion gigas* (Guilding) Swainson.

Molacanthus Swainson, 1839, ibid. **2**: 329. Type: *Molacanthus pallasi* Swainson (= *Tetraodon mola* Linnaeus).

Ozodura Ranzani, 1839, *Novi Comment. acad. Sci. Inst. Bonon.* **3**: 80. Type: *Ozodura orsini* Ranzani.

Tympanomium Ranzani, 1839, ibid., table. Type: *Tympanomium planci* Ranzani.

Trematopsis Ranzani, 1839, ibid., table. Type: *Trematopsis willoughbii* Ranzani.
Pallasina Nardo, 1840, *Ann. Sci. Regno Lombardo-Veneto* **10:** 10, 112. Type: *Pallasina pallasi* Nardo (larval form).
Acanthosoma De Kay, 1842, *Nat. Hist. New York* (*Zool.*) **3:** 330. Type: *Acanthosoma carinatum* De Kay (= *Tetraodon mola* Linnaeus, young).
Aledon Castelnau, 1861, *Mém. Poiss. Afr. austr.*: 75. Type: *Aledon storeri* Castelnau.

Closely related to *Masturus*, but differing in that the clavus is supported entirely by elements from the dorsal and anal fins. The form of the body is relatively shorter, conspicuously so in the young, and the post-larval spines are not entirely lost, the base of one at the chin or one on the snout, or both, remaining as a low bony boss in the largest examples.

Very few post-larval specimens of *Mola* have been found, but the smallest, 5 mm. long, shows that there is an '*Ostracion boops*' stage, and several examples of the secondary post-larval or 'Molacanthus' stage have been described; it is not known whether the 'cornicles' are ever as long as those of *Masturus*.

Although a number of naturalists have believed in the existence of several species of *Mola*, and Ranzani went so far as to recognize five genera and eleven species, it has generally been believed, especially during this century, that only one widely distributed species is admissible.

My studies, however, show that while *Mola mola* is indeed wide-ranging, it is largely or entirely replaced in the South Pacific by a second species, distinguishable as follows:

KEY TO THE SPECIES OF *MOLA*

I. Clavus supported by about 16 rays, 12 of which bear ossicles; the ossicles much broader than the spaces between them, and forming the margin of the clavus; those borne on paraxial rays separate, much smaller than the others. No band of reduced denticles between dorsal and anal fins . . . 1. *ramsayi*

II. Clavus supported by about 12 rays, 8 or 9 of which bear ossicles; the ossicles widely separated, invested with cuticle, which grows beyond them to form lobes in large examples; those borne on paraxial rays united to form a single ossicle larger than all the others. A band of reduced denticles, smoother to the touch, at base of clavus from dorsal to anal fin . . . . . . 2. *mola*.

The term 'paraxial rays' refers to the pair of supporting rays of the clavus the proximal ends of which lie nearest to the end of the vertebral column. The smooth band between dorsal and anal fins in *M. mola* is usually visible, marked by a fold posteriorly, and often differently coloured from the rest of the fish; in doubtful cases the tips of the fingers will discern that this area is less rough than the body in front of it and the clavus behind it.

Mola ramsayi (Giglioli)

Orthagoriscus truncatus Hutton, 1872, *Fish. New Zealand*: 73. (Not of Fleming, 1828.)
Orthagoriscus mola Castelnau, 1872, *Proc. Zool. Acclim. Soc. Vict.* **1:** 211; 1875, *Res. Fish. Austral.*: 3; Hutton, 1873, *Trans. Proc. N.Z. Inst.* **5:** 271; Macleay, 1875, *Proc. Linn. Soc. N.S.W.* **1:** 12; Johnston, 1883, *Pap. Roy. Soc. Tasm.*: 137; 1891, ibid.: 38; Hamilton, 1886,

Trans. Proc. N.Z. Inst. **18:** 135; Williams, 1893, ibid. **25:** 110, pl. 8 *a*; Drew, 1897, ibid. **29:** 286; Parker, 1897, ibid.: 627; ? Fletcher, 1929, *Proc. Linn. Soc. N.S.W.* **54:** 225, 227. (Not of Cuvier, 1817.)

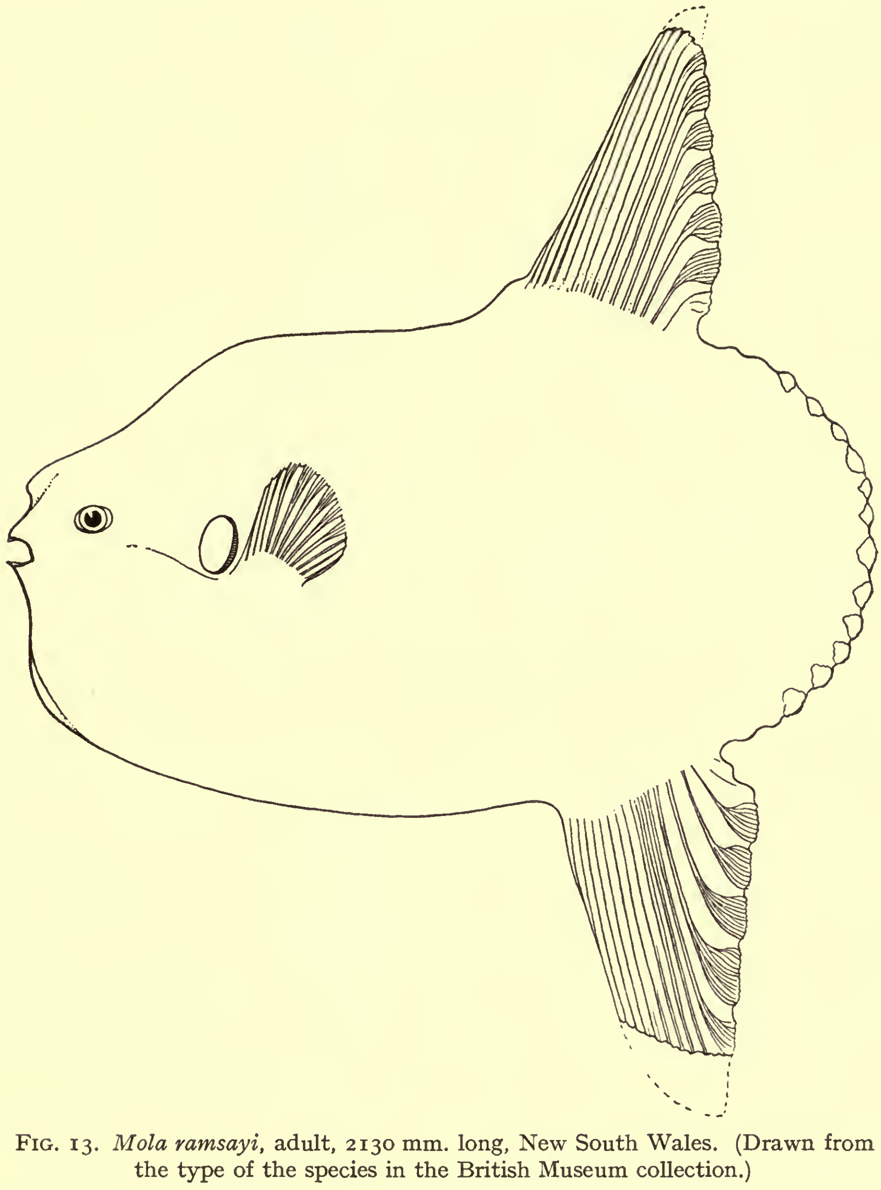

FIG. 13. *Mola ramsayi*, adult, 2130 mm. long, New South Wales. (Drawn from the type of the species in the British Museum collection.)

Orthragoriscus ramsayi Giglioli, 1883, *Nature, Lond.* **28:** 315; Ramsay, 1883, *Cat. N.S.W. Court. Intern. Fish. Exhib.*: 43.

? *Orthagoriscus eurypterus* Philippi, 1893, *Chilen. Fische*: 15, pl. 6, fig. 1 (not seen).

Mola mola Waite, 1907, *Rec. Canterbury* [*N.Z.*] *Mus.* **1:** 34; 1913, *Trans. N.Z. Inst.* **45:** 223, pl. 9; 1921, *Rec. S. Aust. Mus.* **2:** 198, fig. 332; 1923, *Fish. S. Austral.*: 230, fig.; Phillips, 1919,

Rep. Dom. Mus. N.Z.: 6; 1926, *N.Z. J. Sci. Tech.* **8** (3): 169, figs. 1–3; McCulloch, 1922, *Aust. Zool.* **2** (3): 130, fig. 374 *a*; 1930, *Mem. Aust. Mus.* **5** (3): 436 (*part.*); Schneider, 1930,

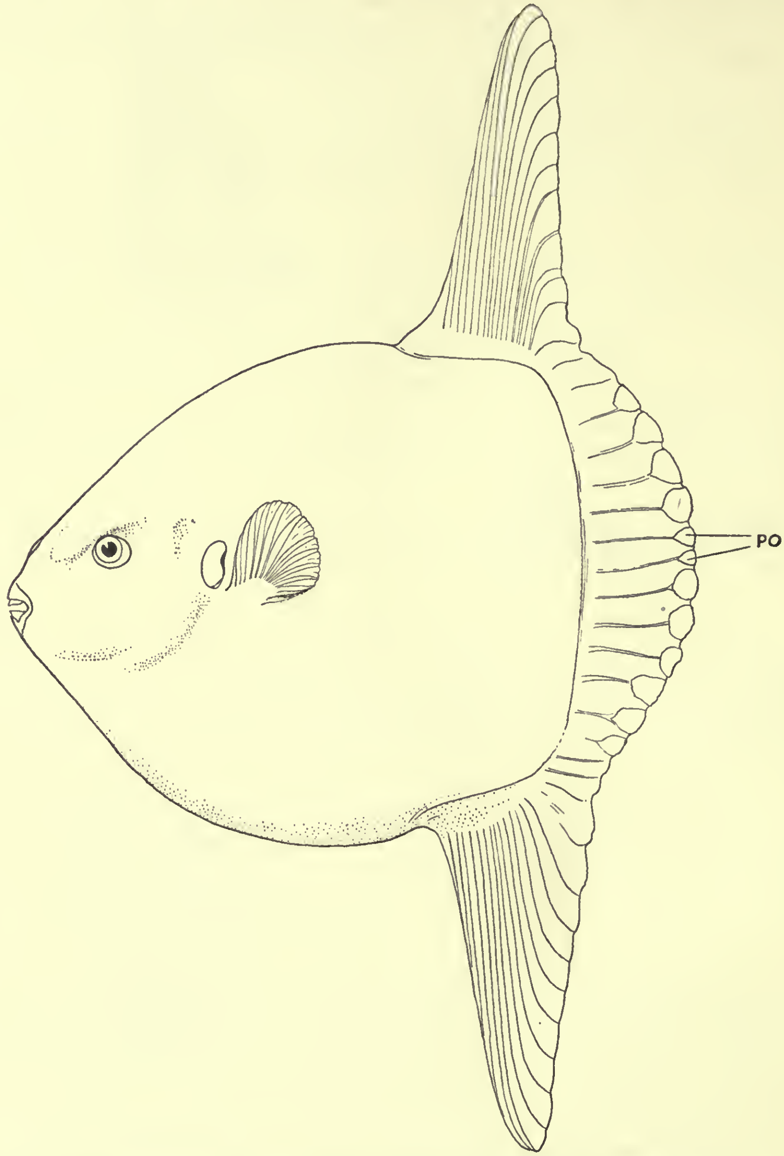

FIG. 14. *Mola ramsayi*, young adult, 410 mm. long, South Australia (?). (From specimen in spirits in the British Museum collection.)
PO, paraxial ossicles.

Rev. Chil. Hist. Nat. **34:** 200, figs. 36, 37; Fowler, 1945, ibid. **45–47:** 170, fig.; Morrow & Mauro 1950, *Copeia*, **1950:** 108, fig. 4 *c*.

Mola ramsayi Whitley, 1931, *Rec. Aust. Mus.* **18** (3): 126 (*part.*), pl. 16, figs. 3, 4.

All the New Zealand records, most of the Australian, and the few Chilean specimens appear to belong to this species, though in many cases it is not possible to be certain. It may be assumed, therefore, that in the South Pacific it replaces the wide-ranging *M. mola*. The two meet, however, in the Australian area, for Stead, McCulloch, and Whitley have all figured specimens which were undoubtedly *M. mola*, Whitley including his specimen with one of the true *M. ramsayi* in the same paper under the latter name.

The type of *Orthragoriscus ramsayi* Giglioli is in the British Museum (Nat. Hist.). Its locality was given as 'Southern Hemisphere', but a label accompanying the specimen states 'New South Wales', and it is known to have been taken on that coast (*fide* Whitley, 1931). It was exhibited at the International Fisheries Exhibition in London in 1883 and later presented to the Museum by the Commissioners of the Exhibition. It is a very large stuffed skin, now in a rather dilapidated condition. The total length is 213 cm. (6 ft. 8 in.).

We have, fortunately, a second specimen, in spirits—much smaller, of course; it is without a definite locality, but almost certainly from South Australia, since it was in a collection of specimens presented by the Zoological Society, several of which were typical South Australian species and all of which would be likely to occur there. It agrees very well with the excellent figure given by Waite (1923), and removes any doubt as to the distinctness of the species from *M. mola*.

The type is not by any means the largest recorded specimen of *M. ramsayi*. That distinction apparently goes to one taken on 12 December 1889 in Poverty Bay, and recorded by Williams as measuring 9 ft. 8 in. and weighing 3½ tons.

Mola mola (Linnaeus)

Tetraodon mola Linnaeus, 1758, *Syst. Nat.* ed. 10, **1**: 334; Pennant, 1776, *Brit. Zool.* **3**: 131, pl.; Migliorini Spinola, 1843, *Poiss. Genes*: 14.

Tetrodon mola Brünnich, 1768, *Ichth. massil.*: 8; Gmelin, 1778, *Syst. Nat. Linn.*: 1447; Retzius, 1785; *K. Svensk. Vetensk. Akad. Handl.* **6**: 115; Bonnaterre, 1788, *Tabl. Encycl. Méth.*: 25, pl. 17, fig. 54; Lacepède, 1798, *Hist. Nat. Poiss.* **1**: 509; Retzius, 1800, *Fauna Suec.*: 310; Donovan, 1803, *Nat. Hist. Brit. Fish.* **2**: pl xxv.

Mola aculeata Koelreuter, 1770, *Novi Comment. Acad. Petropol.* **8**: 337.

Diodon mola Pallas, 1777, *Naturgesch. Thiere* **8**: 41, pl. 4, fig. 7; Bloch, 1785, *Naturgesch. ausländ. Fische* **1**: 75, pl. 128; Jacob. 1826, *Dublin Phil. J.* **2**: 443, pl.

Mola rotunda Cuvier, 1798, *Tabl. Elem. Nat. Hist.*: 323; Jordan, 1881, *Proc. U.S. Nat. Mus.*: 70; Jordan & Gilbert, 1883, *Bull. U.S. Nat. Mus.* **16**: 865; Petersen, 1884, *Vidensk. Medd. naturh. Foren. Kbh.*: 159; Smith, 1885, *W. Amer. Sci.* **1** (7): 45; Linton, 1897, *Proc. U.S. Nat. Mus.* **19**: 788, 812, 824; Steenstrup & Lütken, 1898, *K. Danske vidensk. Selsk. Skr.* (6) **9** (1): 28, pl. 1; Murray & Hjort, 1912, *Depths of the Ocean*: 119, 607, 615, 697, figs. 102, 507; Schmidt, 1921, *Medd. Komm. Havundersøg. Kbh. Fisk.* **6**: 1, figs. 1, 5, 6, 10 *b*, 12, pl. 1, figs. 1, 2; 1926, *Nature, Lond.* **117**: 80, figs. 1, 2; Ehrenbaum, 1936, *Handb. Seefisch. Nordeurop.* **2**: 86, fig. 68; Jensen, 1940, *Vidensk. Medd. nat. Foren. Kbh.* **104**: 319.

Orthragoriscus mola Bloch & Schneider, 1801, *Syst. Ichth.*: 510; Turner, 1862, *Nat. Hist. Rev.*: 185, pl. 6, figs. 4–6; Beneden, 1871, *Mém. Acad. R. Belg.* **38**; Jeude, 1890, *Notes Leyden Mus.* **12**: 189, pl.; Roon & Pelkwijk, 1939, *Zoöl. Meded. Leiden* **22**: 65, figs. 1, 2.

Orthragoriscus fasciatus Bloch & Schneider, 1801, *Syst. Ichth.*: 511.

Orthragoriscus hispidus Bloch & Schneider, 1801, ibid.: 511.

Cephalus brevis Shaw, 1804, *Gen. Zool.* **5**: 437, pl. 175; Neill, 1811, *Mem. Werner. Soc.* **1**: 546; Mitchill, 1815, *Trans. lit. phil. Soc. N.Y.* **1**: 471; Swainson, 1839, *Nat. Hist. Fish.* **1**: 199.

Cephalus pallasianus Shaw, 1804, *Gen. Zool.* **5**: 440.

Orthragus luna Rafinesque, 1810, *Caratt. Sicilia*: 17–18; *Indice Siciliana*: 40.

Diplanchias mola Rafinesque, 1810, ibid.

Cephalus mola Risso, 1810, *Ichth. Nice*: 60; Poey, 1868, *Repert. Cuba* **2**: 433.

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Orthragoriscus nasus Reuvens, 1897, *Notes Leyden Mus.* **18:** 209, pl. 3.

Mola ramsayi Whitley, 1931, *Rec. Aust. Mus.* **18** (3): 126 (*part.*), fig. 2, pl. 16, fig. 1; 1933, *Vict. Nat.* **49:** 210, figs. 1, 2 (not of Giglioli).

Mola alexandrini Barnard, 1948, *Ann. S. Afr. Mus.* **36** (5): 402.

The above extensive synonymy illustrates the considerable literature which has accumulated concerning this species. From a perusal of this data it is possible to give a rather more complete account than for other members of the family, but there is still much of its biology that remains conjectural. The anatomy has been studied broadly and in detail by a number of workers, and from this, together with descriptions or figures giving reliable information about the clavus, it seems quite clear that not more than one species is involved. Published records, considered statistically, would give the impression that the species is mainly a North Atlantic one, becoming rarer southwards, in the Indian Ocean and in the Western Pacific, but this is possibly an illusion due to the much higher rate of publication in the Atlantic and Mediterranean countries.

Certainly the Japanese form is not separable from the Atlantic form, since we have specimens from Japan in our collection for comparison; according to Jordan and Fowler it occurs at Hawaii, and it seems to be common at California, so that it is replaced by *M. ramsayi* only in the South Pacific. I am much indebted to Mr. W. I. Follett, of the California Academy of Sciences, for information and radiographs which enable me to identify the Californian specimens.

A bad practice among some authors is the borrowing of an illustration from some earlier work, especially when the specimen depicted was obtained in a locality remote from that being discussed. *Mola mola* has suffered much from this treatment, and in consequence it is not possible to be definite as to the identity of specimens in regions where *M. ramsayi* might occur also, because the distinguishing characters

of the clavus have been hitherto unknown and are, therefore, not described; a reliable picture might have given the answer.

Comparison of adequate descriptions and figures shows that some order underlies the variability which has been remarked upon by so many authors. After metamorphosis the young fishes are short and deep, the snout not protuberant, the fins rather narrow, and the margin of the clavus is not conspicuously lobed. The length of the clavus from the posterior edge of the 'carapace'—i.e. the anterior edge of the smooth band between dorsal and anal fins—is much less than that of the head. When the fish exceeds a length of about 2 ft., however, sexual differences become apparent. The bony tubercle on the snout is either pushed forward (in the male), or upward (in the female); in consequence the male develops a pronounced snout, projecting forward (the '*nasus*' form), while the female appears more deep-headed, with the front of the snout nearly vertical (the '*alexandrini*' form). As growth proceeds the clavus develops backwards between the ossicles, forming a series of lobes which at first number between 9 and 12 in both sexes; females do not seem to pass beyond this stage, but in large males the five median lobes become very large and the others reduced. After the formation of the lobes the clavus is probably always longer in a male than in a female of the same size, and in the biggest males it may be as long as the head. In large specimens of both sexes two prominent, swollen ridges are formed on each side of the head; these are discernible in small examples, and are evidently analogous if not homologous with the lateral ridges of Ostracionts, but with age they become very conspicuous. In the larger examples also the dorsal and anal fins are relatively much broader.

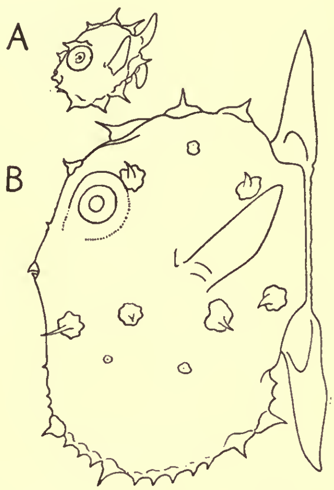

FIG. 15. Post-larvae of *Mola*. A. '*Ostracion boops*' stage (5 mm.). (After Schmidt); B. '*Molacanthus*' stage (16 mm.). (From specimen in the British Museum collection.)

All this is indicated by a study of the records. Comparatively few of the specimens described have been examined for sex, but in each case where the sex is stated the characters mentioned above are found to be associated with it; of particular interest is the paper by Roon & Pelkwijk (1939), who had both sexes and figured them together. Harting's (1868) plate 1 gives a fair representation of a female, and Whitley (1931) has given a drawing of another, together with a photograph of it (pl. xvi, fig. 1), which shows the lateral ridges excellently, and Murray & Hjort's (1912) photograph, copied by Schmidt, illustrates a fine male. The various phases of development outlined do not always coincide with a particular size or age, but are evidently dependent to some extent on environmental circumstances.

Mola mola grows to a great size, the largest record being apparently that by Dean (1913), measuring 10 ft. 1 in. in length and 11 ft. from tip of dorsal fin to tip of anal fin, a male. Mikailovskij (1903) described one measuring 8 ft. 6 in. in length and weighing 1,410 kg. Jeude (1890) described a specimen 2·23 m. (7 ft.) in length,

apparently a female. The specimen recorded by Günther as '7 feet long, Portsmouth' was the fish taken by Parlby (1849), who described its capture at Chesil Beach and

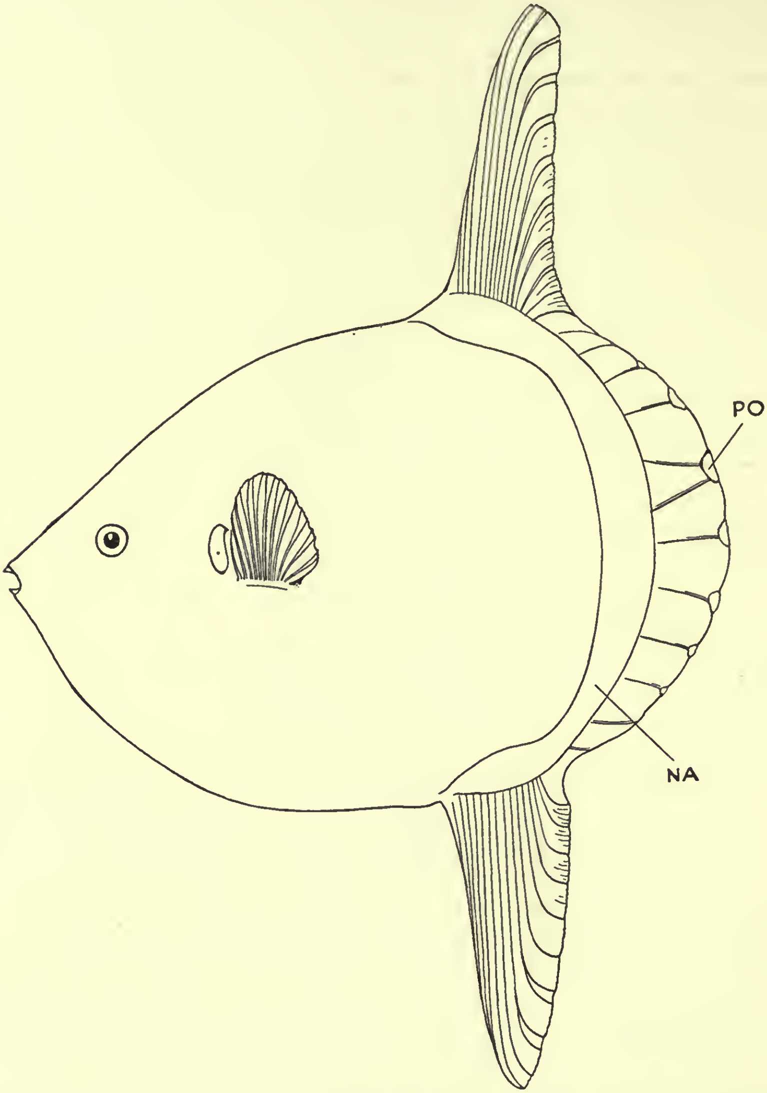

FIG. 16. *Mola mola*, adult, 600 mm. long, Plymouth. (From stuffed specimen in the British Museum collection.)
NA, area of reduced denticles; PO, paraxial ossicle.

stated that it measured 6 ft. 3 in. long. It was probably a male. As a stuffed skin it remained in the British Museum collection until recently, when it was found to be in a bad state and destroyed; my (calliper) measurement at this time reading 5 ft. 8 in., the loss being presumably due to shrinkage (unless Parlby made a contour measure-

ment). A number of smaller stuffed skins and several specimens in spirits remain in the collection. It is never common, the large literature being due to the great interest

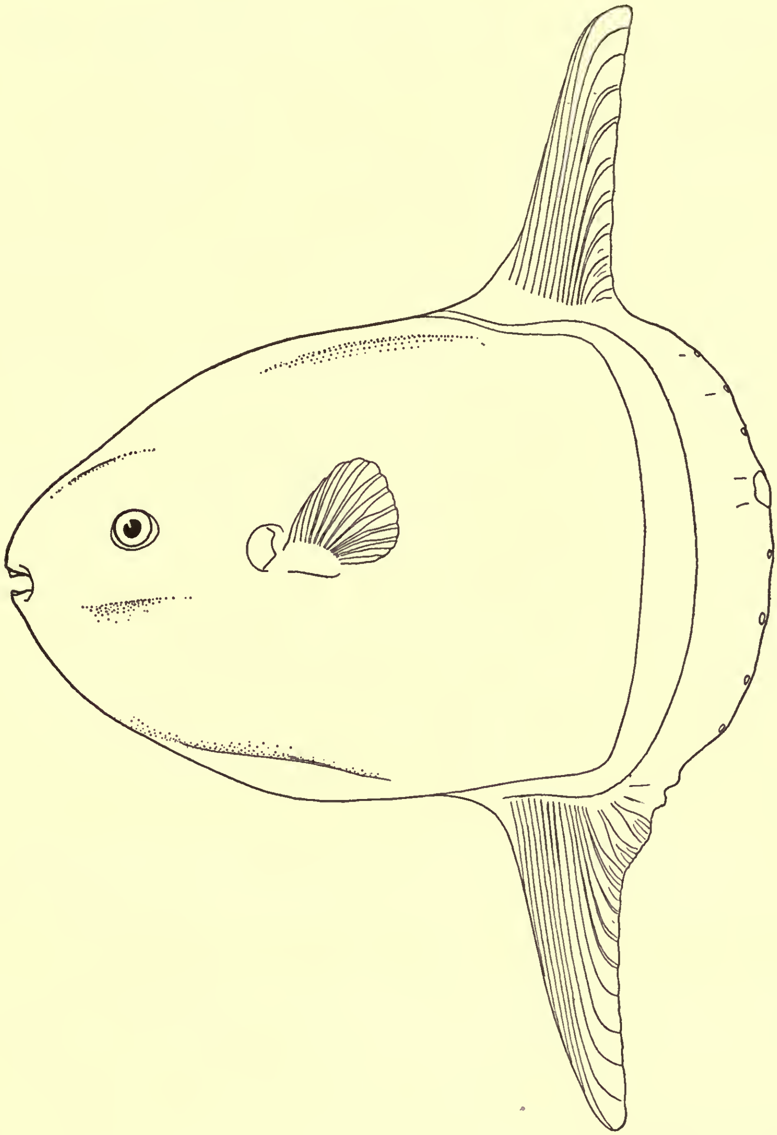

FIG. 17. *Mola mola*, young adult, 366 mm. long, Chouse, Japan. (From specimen in spirits in the British Museum collection.)

it arouses, almost every specimen being reported upon; but it is more frequently met with than any of the previous species. Nevertheless its early developmental stages are less well known than those of *Ranzania*, and fertile eggs or early larvae have not been found; it is not improbable that it spends a great part of its life in deep water.

The scarcity of young specimens is remarkable when we consider that a female 4 ft. 6 in. long contained 300 million eggs. The mode and place of breeding have yet to be found.

Its migrations inshore are unpredictable, and are usually supposed to coincide with invasions of medusae, salps, and ctenophores, upon which it largely feeds. Specimens

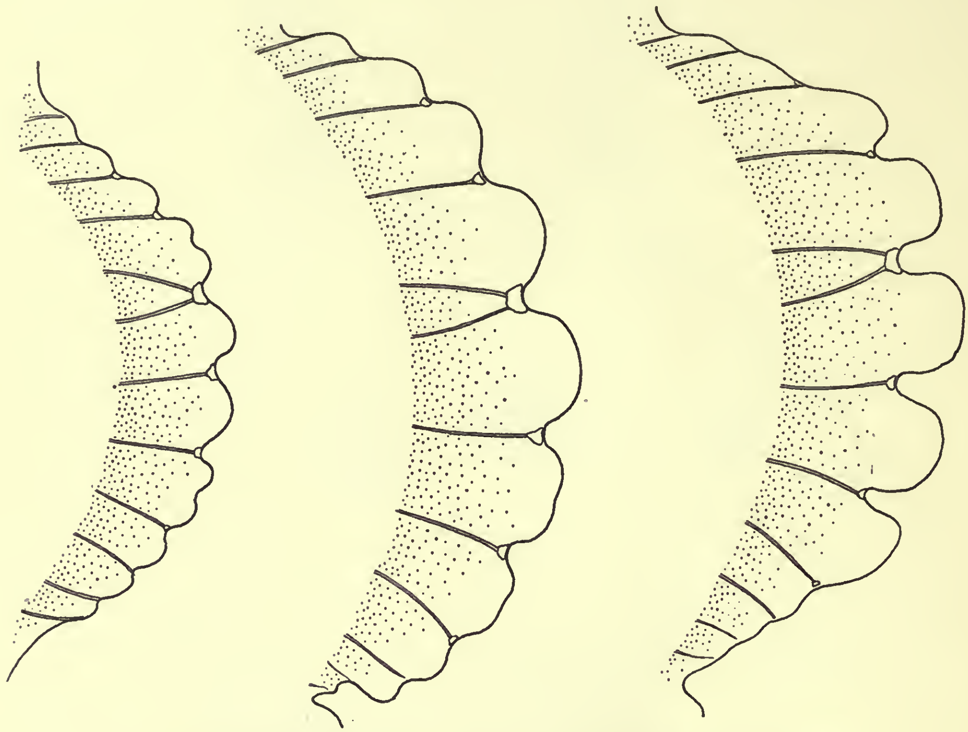

FIG. 18. Different lobulation of the clavus, with similar skeletal supports, in *Mola mola*. Drawn to the same size for comparison. That on the right is the characteristic form in large males.

taken inshore, however, are usually found to be feeding on littoral forms, and the list of organisms taken from stomachs includes crustacea, ophiuroids, molluscs, hydroids, ctenophores, corallines, and algae; Schmidt has reported them as feeding heavily on *leptocephali*; on one occasion a flounder (*Platichthys flesus*) was found in the throat (Reuvens, 1897), and in our collection there is a ling (*Molva macrophthalma*) two feet long which was taken from the stomach of *Mola mola*. The stomach is not infrequently found to be empty, and it is quite probable that the specimens so frequently taken without difficulty while 'basking' at the surface are in fact sick or dying fish. Myers & Wales (1930) found young fish to be active and alert, but later found two larger fish 'disabled' at the surface. It would be interesting to know the cause of such disablement. Possibly the great variety of parasites with which they are often found to be infested may have some bearing on the matter.

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ZOOLOGY Vol. 1 No. 7
LONDON : 1952

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

Parts appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 7, of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued January 1952 Price Twelve shillings and sixpence

THE CESTODES OF SEALS FROM THE ANTARCTIC

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SYNOPSIS

The present paper reviews and re-describes all known Pseudophyllidean Cestodes occurring in the five species of Antarctic Seals, namely, Weddell seal, Leopard seal, Crabeater seal, Elephant seal, and Ross seal. According to the literature, twelve species belonging to two genera have been previously recorded from these hosts.

The investigation of material collected by the British Graham Land Expedition, together with a comparative study of type-specimens collected by other Antarctic expeditions, leads to the conclusion that there are nine species of Pseudophyllidean Cestodes occurring in these hosts. These belong to four genera, two of which are new and of these, one represents a new species.

From the twelve species quoted in the literature, three are here placed in synonymy and one transferred to another genus.

MATERIAL AND METHODS

THE bulk of the material for this study was collected by the British Graham Land Expedition during 1934–1937. In addition, some samples gathered by the *Discovery* in 1925, 1928, and 1931, and by the 'Falkland Islands Dependencies Survey' in 1945, have been examined for comparative purposes. The material obtained by the British Graham Land Expedition comprises 33 lots from Weddell seals (*Leptonychotes weddelli*), 12 from Leopard seals (*Hydrurga leptonyx*), 6 from Crabeater seals (*Lobodon carcinophagus*), and 2 from Elephant seals (*Macrorhinus leoninus*). The *Discovery* material consists of 5 lots from Leopard seals and 1 from a Crabeater seal, and that of the 'Falkland Islands Dependencies Survey' of 2 lots only from Weddell seals. Thus the 61 batches of specimens investigated can be summarized as follows: 35 from Weddell seals, 17 from Leopard seals, 7 from Crabeater seals, and 2 from Elephant seals.

The British Graham Land Expedition's material was obtained from Graham Land (Debenham Is., Horseshoe I., Argentine Is., and Beascochea Bay), South Shetland (Deception I.), Palmer Archipelago (Melchoir I.), and South Georgia (Cooper Bay and Bay of Isles). The *Discovery* material was collected from South Orkneys (Coronation I.), South Georgia (Maivicken), and South Sandwich Is. The 'Falkland Islands Dependencies Survey' from Graham Land (Hut Cove, Hope Bay) and Palmer Archipelago (Port Lockroy, Wiencke I.). Preservation was in 4 per cent. formalin or, occasionally, in Bouin's Solution. The material comprises mainly portions of the gut with Cestodes attached to the walls, and individual specimens are, with a few exceptions, perfectly extended.

In addition to the new material, numerous collections from the same host-species were examined. These included the type-specimens described by Baird (1853), Shipley (1907), Rennie & Reid (1912), and Leiper & Atkinson (1914). The collection

of Fuhrmann consisted of microscopical preparations of specimens, probably types, of Linstow (1892), of Railliet & Henry (1912), and material described by Fuhrmann (1920) himself. Some of the material in these collections is not in very good condition, the specimens mounted whole or as serial sections having partially lost their stains.

Over 1,200 slides of the present material have been made. Whole preparations have been stained with Mayer's paracarmine or alum carmine, and serial sections, $10\,\mu$ to $18\,\mu$ in thickness, have been double-stained with Ehrlich's haematoxylin and erythrosin.

I have great pleasure in expressing my heartiest thanks to Dr. H. A. Baylis, who kindly suggested this investigation and provided the necessary materials; to Dr. H. W. Parker, Keeper of the Department of Zoology, British Museum (Natural History); to Dr. M. Burton; and to Mr. S. Prudhoe for his valuable assistance. In addition, I wish to express my thanks to Professor J. G. Baer, Rector of the University of Neuchâtel, for his kindness in lending me the collection of slides left by the late Professor O. Fuhrmann, and to Dr. G. C. L. Bertram, of St. John's College, Cambridge, for information on the Graham Land Seals.

HISTORICAL

Our knowledge of Cestodes occurring in the Antarctic seals has been obtained almost exclusively from various Antarctic expeditions, including five British, one Australian, one French, and two German expeditions.

The first specimens were collected in 1839–1843 by Ross's Antarctic Expedition from a *Phoca* sp.—probably the Ross seal—and described by Baird (1853) as *Bothriocephalus antarcticus*. Further samples were collected from the Ross seal by the National Antarctic Expedition (*Discovery*) in 1901–1904 and described by Shipley (1907) under the name *Dibothriocephalus antarcticus*. Railliet & Henry (1912) studied this species from material collected from the Ross seal by the Second French Antarctic Expedition of Dr. J. Charcot (*Pourquoi Pas?*) 1908–1910 and described it as *Diphyllobothrium antarcticum*. Finally, Fuhrmann (1920)[1] re-examined the type-specimens and made the species the type of a new genus, *Glandicephalus*, characterized by the peculiar development of the musculature of the body, by the arrangement of the testes, and by the presence of gland-cells in the scolex. Johnston (1937) mentions the species as having been found in the Ross seal by the Australasian Expedition, 1911–1914.

Linstow (1892) described as *Bothriocephalus tectus* headless specimens from Elephant seals, collected at South Georgia by the German Expedition in 1882–1883. This was also recorded by Linstow in Shipley (1902) from the Ross seal, collected by the *Southern Cross* Expedition, 1898–1900, and by Johnston (1937) from the Elephant seal, in the collection of the Australasian Antarctic Expedition.

Diphyllobothrium quadratum (Linstow 1892) was collected for the first time from the Leopard seal by the German Expedition, 1882–1883, in South Georgia and in 1902–1904 by the Scottish National Antarctic Expedition (*Scotia*). It was re-described

[1] Fuhrmann's paper was published in 1920 (December) and not in 1921, as is often quoted.

by Rennie & Reid (1912) as *Bothriocephalus coatsi*, from the same host. Railliet & Henry (1912) recorded this species as *Diphyllobothrium resimum*, collected by the Second French Antarctic Expedition. Later, Fuhrmann (1920) gave a description of *D. quadratum*, collected by the German South Pole Expedition, 1901–1903, and regarded *Bothriocephalus coatsi* (Rennie & Reid, 1912) and *Diphyllobothrium resimum* (Railliet & Henry, 1912) as synonyms of that name. Finally, Johnston (1937) gave a few further details of the species, based on material from the Leopard seal, collected by the Australasian Antarctic Expedition.

Shipley (1907) described *Diphyllobothrium wilsoni* and *D. scotti*, the first being obtained from the Weddell seal and the Ross seal, and the second from the Ross seal, both having been collected by the National Antarctic Expedition, 1901–1904. They were re-described by Fuhrmann (1920) from the material obtained by the German South Pole Expedition (1901–1905) from the Ross seal and Leopard seal. They are also reported by Johnston (1937) from the Ross seal and the Weddell seal collected by the Australasian Antarctic Expedition.

Diphyllobothrium mobile (Rennie & Reid, 1912) from the Weddell seal and *D. scoticum* (Rennie & Reid, 1912) from the Leopard seal were collected for the first time by the Scottish National Antarctic Expedition in 1902–1904 and described by Rennie & Reid (1912) under the generic name *Dibothriocephalus*. Fuhrmann (1920) gives a full re-description of both these species from the Ross seal and the Weddell seal, and of *D. scoticum* from the Leopard seal, collected by the German South Pole Expedition in 1901–1903. Both species were studied by Johnston (1937) from material from the Weddell seal and the Leopard seal, collected by the Australasian Antarctic Expedition.

Diphyllobothrium perfoliatum Railliet & Henry, 1912, described also as *D. clavatum* in the same work, was collected for the first time by the Second French Antarctic Expedition from the Weddell seal. It was re-described by Leiper & Atkinson (1915) from material collected by the British Antarctic (*Terra Nova*) Expedition 1910 and by Fuhrmann (1920) from material collected by the German South Pole Expedition under the name *Dibothriocephalus perfoliatus*. In both cases the material was taken from the same host. Fuhrmann (1920) recognized *D. clavatum* as a synonym of *D. perfoliatum*. This Cestode is also mentioned by Johnston (1937) in a collection made by the Australasian Antarctic Expedition.

Diphyllobothrium rufum Leiper & Atkinson, 1914, collected by the *Terra Nova* Expedition in 1910, is considered by Johnston (1937) as 'a short-necked, precocious form of *D. perfoliatum*', found in the Weddel seal by the Australasian Antarctic Expedition.

The last two species, *Diphyllobothrium lashleyi* and *D. archeri*, were both described by Leiper & Atkinson (1914) from the Weddell seal gathered by the *Terra Nova* Expedition. The first of these species was re-described by Johnston (1937) from material from the same host-species collected by the Australasian Antarctic Expedition 1911–1914.

To sum up, 9 species have been described from the material collected by the British Antarctic Expeditions, 4 by the French, and 2 by the two German Expeditions.

The details of the result of each expedition are shown in Table No. 1.

Table No. 1

A list of the Cestodes from Seals, collected by Antarctic Expeditions during the period 1839–1914

Expeditions	*Parasite*	*Host*
Ross's Antarctic Exp. 1839–1843	*Glandicephalus antarcticus* (Baird, 1853)	*Phoca* sp., probably Ross seal
Southern Cross Antarctic Exp. 1898–1900	*Diphyllobothrium tectum* (Linstow, 1892)	*Ommatophoca rossi*
National Antarctic Exp. (*Discovery*) 1901–1909	,, *scotti* (Shipley, 1907)	,,
	,, *wilsoni* (Shipley, 1907)	,,
	Glandicephalus antarcticus (Baird, 1853)	,,
Scottish National Antarctic Exp. (*Scotia*) 1902–1904	,, *antarcticus* (Baird, 1853)	,,
	Diphyllobothrium coatsi (Rennie & Reid, 1912)	*Hydrurga leptonyx*
	,, *mobile* (Rennie & Reid, 1912)	*Leptonychotes weddelli*
	,, *scoticum* (Rennie & Reid, 1912)	*Hydrurga leptonyx*
	Phyllobothrium sp. (larva) Rennie & Reid, 1912	*Leptonychotes weddelli*
British Antarctic Exp. (*Terra Nova*) 1910–1913	*Diphyllobothrium mobile* (Rennie & Reid, 1912)	,,
	,, *coatsi* (Rennie & Reid, 1912)	,,
	,, *perfoliatum* (Railliet & Henry, 1912)	,,
	,, *archeri* (Leiper & Atkinson, 1914)	,,
	,, *lashleyi* (Leiper & Atkinson, 1914)	,,
	,, *rufum* (Leiper & Atkinson, 1914)	,,
Australasian Antarctic Exp. 1911–1914	,, *perfoliatum* Railliet & Henry, 1912	,,
	,, *lashleyi* (Leiper & Atkinson, 1914)	,,
	,, *wilsoni* (Shipley, 1907)	,,
	,, *rufum* Leiper & Atkinson, 1914	,,
	,, *mobile* (Rennie & Reid, 1912)	,,
	,, *quadratum* (Linstow, 1892)	*Hydrurga leptonyx*
	,, *scoticum* (Rennie & Reid, 1912)	,,
	,, *scotti* (Shipley, 1907)	*Ommatophoca rossi*
	,, *wilsoni* (Shipley, 1907)	,,
	,, *mobile* (Rennie & Reid, 1912)	,,
	Glandicephalus antarcticus (Baird, 1853)	,,
	Diphyllobothrium tectum (Linstow, 1892)	*Mirounga leonina*
	Phyllobothrium sp. (larva)	,,
German Antarctic Exp., South Georgia, 1882–1883	*Diphyllobothrium tectum* (Linstow, 1892)	*Mirounga leonina*
	,, *quadratum* (Linstow, 1892)	*Hydrurga leptonyx*
German Antarctic Exp. (*Gauss*) 1901–1903	,, *perfoliatum* Railliet & Henry, 1912	*Leptonychotes weddelli*
	,, *quadratum* (Linstow, 1892)	*Hydrurga leptonyx*
	,, *wilsoni* (Shipley, 1907)	*Ommatophoca rossi*, *Hydrurga leptonyx*
	,, *mobile* (Rennie & Reid, 1912)	*Ommatophoca rossi*, *Leptonychotes weddelli*

TABLE No. 1 (*continued*)

Expeditions	*Parasite*	*Host*
2nd French Antarctic Exp. (*Pourquoi Pas?*) 1908–1910, Dr. J. Charcot	*Diphyllobothrium resimum* Railliet & Henry, 1912	*Hydrurga leptonyx*
	,, *wilsoni* (Shipley, 1907)	*Leptonychotes weddelli*
	,, *perfoliatum* Railliet & Henry, 1912	,,
	,, *clavatum* Railliet & Henry, 1912	,,
	,, sp. ? Railliet & Henry, 1912	*Ommatophoca rossi*
	Glandicephalus antarcticus (Baird, 1853)	,,
	Cestoda (unidentified)	*Lobodon carcinophagus*

The species enumerated above have been listed by Meggitt (1924) and Stunkard & Schoenborn (1936), though all these authors appear to have overlooked the work of Fuhrmann (1920), who reduced the number of species to twelve, apportioned between two genera, *Diphyllobothrium* and *Glandicephalus*.[1]

Wardle, McLeod, & Stewart (1947) have proposed a new classification of the genus *Diphyllobothrium*, but this appears to have been based mainly upon information obtained from the literature. Stunkard's (1948) criticism of the classification is fully subscribed to by the present writer.

DISCUSSION

After investigation of the new material it seems that the Pseudophyllidean Cestodes occurring in the Antarctic seals represent no more than 4 genera and 9 species namely:

1. *Diphyllobothrium lashleyi* (Leiper & Atkinson, 1914).
2. *D. mobile* (Rennie & Reid, 1912).
3. *D. quadratum* (Linstow, 1892).
4. *D. scoticum* (Rennie & Reid, 1912).
5. *D. wilsoni* (Shipley, 1907).
6. *Glandicephalus antarcticus* (Baird, 1853).
7. *G.* [*Diphyllobothrium*] *perfoliatus* (Railliet & Henry, 1912).
8. *Baylisia baylisi* gen. nov., spec. nov.
9. *Baylisiella tecta* (Linstow, 1892) gen. nov.

The details of their anatomical differences are given in Table No. 2.

Of the five species of *Diphyllobothrium* mentioned above, *D. lashleyi* alone possesses a well-developed distinct neck and the rudiments of genital organs at some distance behind it. In this it resembles both species of *Glandicephalus*. The rest of the species of *Diphyllobothrium* possess a very short indistinct neck, the presence of which has

[1] In addition, unidentified Cestodes have been recorded from the Crabeater seal by Railliet & Henry (1912); and the larval stages of *Phyllobothrium* in the blubber of the Weddell seal by Rennie & Reid (1912) and Fuhrmann (1931). *Phyllobothrium delphini* (Bosc, 1802) Gervais, 1885, found by J. E. Hamilton in 1931 in the blubber of the Leopard seal at Falkland Islands is reported by Southwell & Walker (1936), and the larval stage of *Phyllobothrium* from Elephant seal by Johnston (1937).

TABLE NO. 2

Comparative data of the species occurring in the Antarctic Seals, based on the writer's material

Parasite	*D. lashleyi*	*D. mobile*	*D. quadratum*	*D. scoticum*	*D. wilsoni*	*? D. spec.*	*G. perfoliatus*	*G. antarcticus*	*Baylisia, baylisi gen. nov. spec. nov.*	*Baylisiella tecta gen. nov.*
Body: length . . .	19·5 cm.	14 mm.	12 cm.	130 cm.	5 cm.	7 mm.	20 cm.	10 cm.	126 cm.	32 cm.
width . . .	3 mm.	510 μ	4·5 mm.	1·8 cm.	3 mm.	480 μ	7 mm.	7 mm.	8 mm.	2 cm.
Scolex: length . .	1·5 mm.	825 μ	1·8 mm.	3·5 mm.	825 μ	675 μ	3·5 mm.	3 mm.	900 μ	8 mm.
width . .	1·3 mm.	510 μ	1·4 mm.	2 mm.	450 μ	480 μ	2 mm.	2 mm.	1·3 mm.	5 mm.
Neck: length . .	450 μ–2·5 mm.	300 μ	1·5 mm.	495 μ	375 μ	absent	3 mm.	2·35 mm.	? absent	? absent
width . . .	975 μ	495 μ	870 μ	825 μ	240 μ	. .	1 mm.	750 μ	. .	. .
Cirrus-sac: length . .	200 μ	112 μ	300 μ	231 μ	165 μ	?	264 μ	462 μ	750 μ	450 μ
width . .	93 μ	66 μ	60 μ	142 μ	99 μ	?	188 μ	231 μ	180 μ	150 μ
Vesicula seminalis: size .	69 μ × 55 μ	83 μ × 50 μ	120 μ × 105 μ	285 μ × 180 μ	92 μ × 56 μ	?	132 μ × 148 μ	132 μ × 155 μ	198 μ × 99 μ	195 μ × 180 μ
Vesicula seminalis: wall thickness . . .	17 μ	10 μ	17 μ	17 μ	20 μ	?	20 μ	10 μ	33 μ–50 μ	30 μ
Distribution of testes .	single layer confluent anterior	single layer occur in anterior part of segment	single layer confluent anterior	single layer two separate fields	single layer confluent anterior	? ? ?	irregular single layer	scattered irregularly	single layer	2 or 3 layers
Approx. No. of testes .	120	40	340	600	150	?	100	?	36	?
No. of testes on each side in transverse section .	2–6	5	12–16	15	8	?	14	?	18	45
No. of testes in sagittal section . . .	10–17	7	12–16	25	6–8	?	3–6	?	1	2–3
Testes: size . . .	53 μ × 93 μ	66 μ × 99 μ	65 μ × 78 μ	150 μ × 210 μ	99 μ × 132 μ	?	172 μ × 93 μ	66 μ–116 μ × 59 μ–92 μ	116 μ × 40 μ	132 μ × 86 μ
Eggs: size . . .	56 μ × 44 μ	60 μ × 43 μ	56 μ × 43 μ	79 μ × 56 μ	50 μ × 40 μ	?	66 μ × 50 μ	50 μ × 33 μ	66 μ × 46 μ	66 μ × 46 μ
Vitelline glands: size .	33 μ × 50 μ	33 μ	50 μ × 33 μ	60 μ × 105 μ	66 μ × 50 μ	?	70 μ × 40 μ	40 μ × 50 μ	43 μ × 20 μ	66 μ × 26 μ
No. of cortical excretory vessels . . .	28	?	34	20	14	?	16	30	76	108
Thickness of longitudinal muscle-layer . .	20 μ	4 μ	33 μ	150 μ	17 μ	?	300 μ	? 450 μ	450 μ	555 μ
Host	Weddell seal	Weddell seal	Leopard seal	Leopard seal	Leopard seal, Weddell seal	Crabeater seal	Weddell seal	Ross seal	Crabeater seal	Elephant seal

PLATE 10, FIGS. 1–9

ABBREVIATIONS USED: *c.*, cirrus; *c.b.*, 'calcareous body'; *c.g.*, cephalic glands; *c.s.*, cirrus-sac; *d.v.m.*, dorso-ventral musculature; *ex*, excretory system; *g*, glands; *g.p.*, genital papillae; *l.m.*, longitudinal musculature; *m*, muscles; *n*, nerve; *o*, ovary; *oc.*, oocapt; *r.s.*, receptaculum seminis; *s.g.*, shell-gland; *t.*, testis; *t.m.*, transverse musculature; *u.*, uterus; *v.*, vagina; *v.d.*, vas deferens; *v.g.*, vitelline glands; *v.s.*, vesicula seminalis; *y.r.*, yolk reservoir.

FIG. 1. *Diphyllobothrium lashleyi* from Weddell seal. Sagittal section of cirrus-sac.

FIG. 2. *D. mobile* from Weddell seal. Sagittal section of cirrus-sac.

FIG. 3. *D. quadratum* from Leopard seal. Sagittal section of cirrus-sac.

FIG. 4. *D. scoticum* from Leopard seal. Sagittal section showing glandular cells.

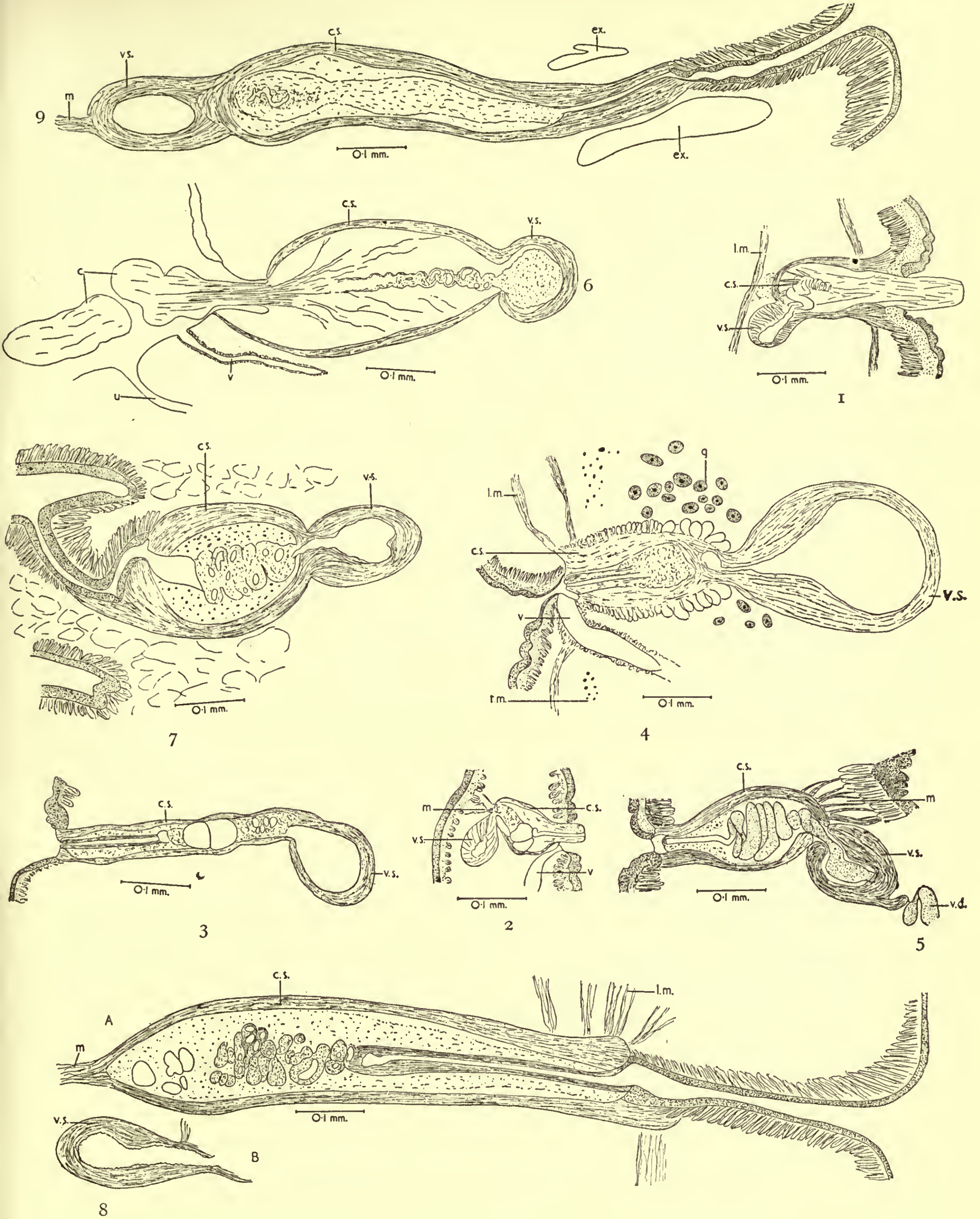
FIG. 5. *D. wilsoni* from Weddell seal. Sagittal section of cirrus-sac, with coiled cirrus showing muscle-fibres attached to the dorsal wall of the segment.

FIG. 6. *Glandicephalus antarcticus* from Ross seal. Sagittal section of cirrus-sac.

FIG. 7. *Glandicephalus perfoliatus* from Weddell seal. Sagittal section of cirrus-sac.

FIG. 8. *Baylisia baylisi* from Crabeater seal. (*a*) Sagittal section of cirrus-sac. (*b*) Vesicula seminalis in the same section.

FIG. 9. *Baylisiella tecta* from Elephant seal. Sagittal section of cirrus-sac.


9
m
v.s.
c.s.
ex.
ex.
0·1 mm.
6
c
c.s.
v.s.
v
u
0·1 mm.
1
l.m.
c.s.
v.s.
0·1 mm.
7
c.s.
v.s.
0·1 mm.
4
g
l.m.
c.s.
v
v.s.
l.m.
0·1 mm.
3
c.s.
v.s.
0·1 mm.
2
m
c.s.
v.s.
v
0·1 mm.
5
c.s.
m
v.s.
v.d.
0·1 mm.
8
A
B
c.s.
l.m.
m
v.s.
0·1 mm.

FIGS. 1–9

♀

often been questioned by previous authors. The neck of these species of *Diphyllobothrium* is extremely short, no more than a continuation of the scolex, and the rudiments of the genital organs occur in the immediate vicinity of the neck, usually in the second segment.

Diphyllobothrium perfoliatum Railliet & Henry, 1912, has been transferred by the present writer to the genus *Glandicephalus* Fuhrmann (1920), owing to the peculiar structure of its longitudinal musculature, which is almost identical with the musculature in *G. antarcticus*. In addition, there is a similar, though not identical distribution of the testes. Both these features were stressed by Fuhrmann (1920) in his original diagnosis. Both species also possess imbricated proglottids, though these are less developed in *G. antarcticus*. The name *Glandicephalus* is not very appropriate, as cephalic glands may also occur in species of *Diphyllobothrium*. On the other hand, cephalic glands have not been found in the scolex of *Glandicephalus perfoliatus* stained with Ehrlich's haematoxylin. Nevertheless, on anatomical grounds it finds its closest affinities in *G. antarcticus*.

It would seem that the cirrus-sac of the male genital apparatus, examined in sagittal section, and the longitudinal musculature, seen in transverse section, give the best means of determining species. This is true not only for *Diphyllobothrium* but for the other forms dealt with here. Earlier writers paid much more attention to the size of the body, shape and size of the scolex and of the neck, and the number, shape, and size of the segments.

More attention was paid to the female genital system than to that of the male. Such features as the shape and number of the uterine coils, the size and shape of the ovary, and the size of the eggs and vitelline glands were considered significant, as well as the position of the external openings of the genital apparatus. In some cases the presence of cephalic glands in the scolex was accepted as a generic difference (Nybelin, 1931).

There is nothing more deceptive in the species of *Diphyllobothrium* than the size of the body, its length and width. For example, *D. lashleyi* may vary from 4·5 cm. to 19·5 cm. in length in the adult. Greater differences in length, observed in new material, have been recorded for *D. scoticum*, which varies from 13 cm. to 130 cm., and for *D. wilsoni* from 10 mm. to 50 mm. The number of segments also is variable.

The scolex is also of a doubtful value, as its size and shape depends much on the fixatives used. Only in a few cases does it present distinct morphological differences.

The presence of cephalic glands in the scolex has been demonstrated in *D. lashleyi*, *D. mobile*, and *D. quadratum* by using Ehrlich's haematoxylin. They were also found to occur in the scolex of *Glandicephalus antarcticus* by Fuhrmann (1920) and by Nybelin (1931) in *Adenocephalus*. This means that they occur in widely different genera. This feature cannot therefore be used for generic distinction. Only in *D. scoticum*, *Baylisia baylisi*, and *Baylisiella tecta* does the scolex show characteristic differences as compared with the other species mentioned in this paper.

The neck is extremely variable in size and possesses a diagnostic value only when it constitutes a well-marked feature. As previously stated, a neck is present in *D. lasheyi* and is also fairly well developed in *Glandicephalus antarcticus* and *G. perfoliatus*. In *D. lashleyi*, however, it is so contracted in some cases that the specimen gives an

impression of being without a neck and, as a consequence, of belonging to another species.

Owing to this variation of the neck Leiper & Atkinson (1914) described *Diphyllobothrium rufum* as a separate species, but it now appears to be a synonym of *G. perfoliatus*. *D. rufum* was distinguished by the absence of a neck, an effect which might be caused by contraction, and by 'notches' in the imbricated portions of the segments.

The female genital apparatus is of little use for purposes of identification. The uterus is a more or less irregular sac, filled with eggs, with the opening, in the majority of cases, irregularly alternate. Only in *D. scoticum* is the terminal part of the uterus modified to form a characteristic 'pocket' lined with villous tissues.

The ovary also varies considerably in shape and size, even in the same strobila. In *D. lashleyi*, for instance, the ovaries in squarish segments are entirely different in shape to those in elongate segments.

The sizes of eggs, given in Table No. 2, do not show any remarkable difference, except in *D. scoticum*, but this differs from other species in many other anatomical details, much more distinct than the size of the eggs.

The vitelline glands, forming a continuous field along the strobila and covering internal structures in all species, have a characteristic form only in *D. mobile*, where this continuous field is interrupted by the transverse segmentation of the body.

The excretory system, proposed as a criterion for identification of some of the Cestodes from seals by Zschokke (1903), is also uncertain since it undergoes changes during the fixation and the consequent contraction of the body.

An excretory system occurs in the cortical and medullary parenchyma in the Cestodes of the Antarctic seals belonging to the species of *Diphyllobothrium*, although in the present material of *D. mobile* no excretory system has been detected. In *Baylisia baylisi* and *Baylisiella tecta* the system seems to be present only in the cortical parenchyma, where it reaches a high degree of development.

The most essential specific differences occur in the male genital apparatus and in the development of the longitudinal musculature, as well as in the relation of this musculature to the transverse and the dorso-ventral muscles. The cirrus-sac, examined in sagittal section, differs specifically in shape and size. Plate 10, figs. 1–9, shows these morphological differences exhibited by the various species enumerated in this paper. The size, shape, and position of the vesicula seminalis in relation to the cirrus-sac may be very variable in some species, but in others it is sufficiently constant to have a taxonomic value. The testes, which in the species of *Diphyllobothrium* occur in two lateral fields, are arranged in a single layer and are usually confluent in the anterior part of the segment. In *D. mobile*, however, they are arranged in one field in the anterior part of the segment, and in *D. scoticum* they form two separate fields, one at each side of the segment. The two species of *Glandicephalus* have testes scattered more or less irregularly. The same arrangement occurs in *Baylisiella tecta*. In the last case the precise number of testes occurring in the segment is difficult to determine, the more so as they are arranged in several irregular layers. The number of testes per segment has not, therefore, any value as a taxonomic criterion in *Baylisiella*. The numbers of the testes counted in transverse and sagittal

PLATE 11, FIGS. 10–18

(*For list of abbreviations see Plate* 10)

FIG. 10. *Diphyllobothrium lashleyi* from Weddell seal. Transverse section of muscular system.

FIG. 11. *D. mobile* from Weddell seal. Transverse section of muscular system.

FIG. 12. *D. quadratum* from Leopard seal. Transverse section of muscular system.

FIG. 13. *D. scoticum* from Leopard seal. Transverse section of muscular system.

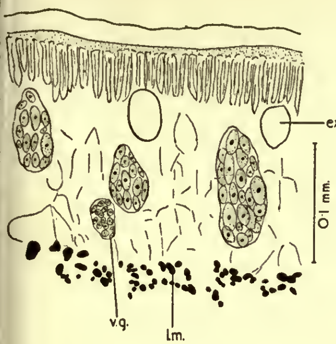
FIG. 14. *D. wilsoni* from Weddell seal. Transverse section of muscular system.

FIG. 15. *Glandicephalus antarcticus* from Ross seal. Transverse section of muscular system, showing network formed by transverse and dorso-ventral musculature, enclosing in its 'meshes' the longitudinal muscle-fibres.

FIG. 16. *Glandicephalus perfoliatus* from Weddell seal. Transverse section of muscular system, showing similar structure as in *G. antarcticus*. Upper part of cortical parenchyma has not been depicted.

FIG. 17. *Baylisia baylisi* from Crabeater seal. Transverse section of muscular system.

FIG. 18. *Baylisiella tecta* from Elephant seal. Transverse section of muscular system, showing its peculiar structure and the powerfully developed cortical excretory system. Only a part of cortical parenchyma and vitelline glands have been drawn.



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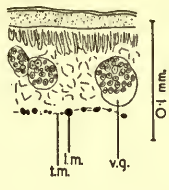

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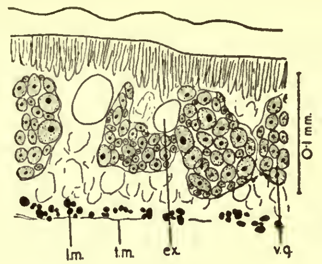

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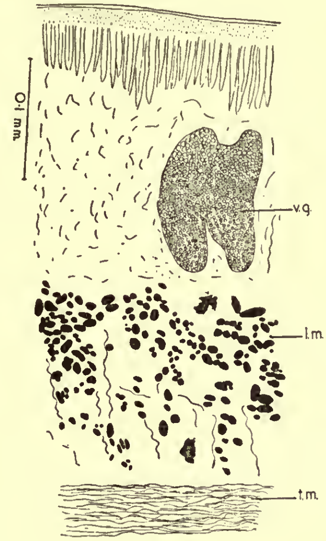

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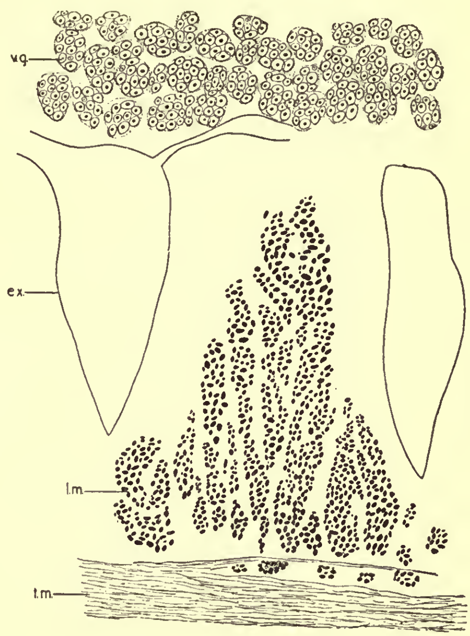

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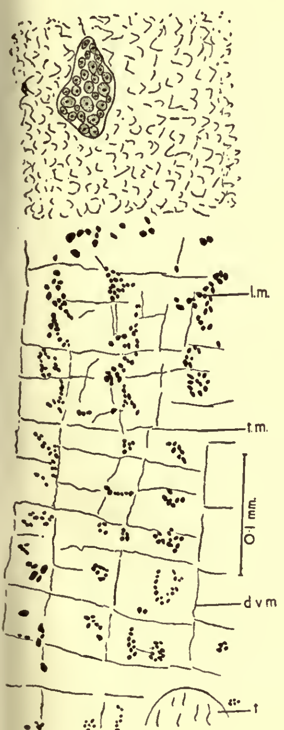

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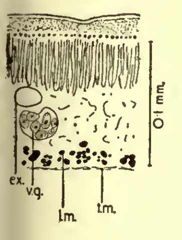

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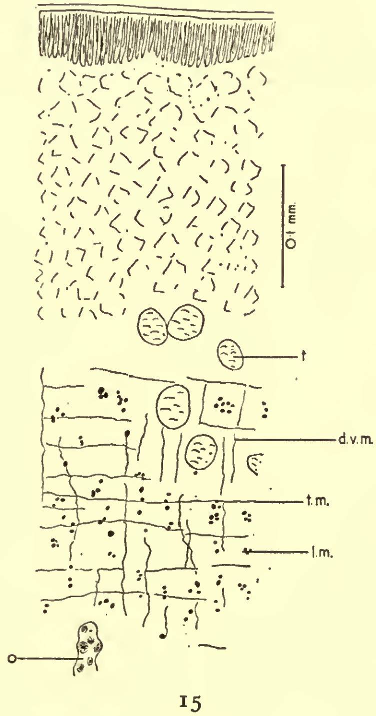

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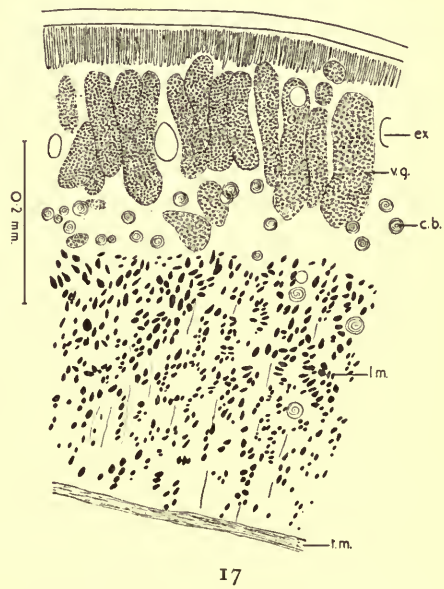

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FIGS. 10–18

sections, shown in the Table No. 2, are more constant for a given species, although the numbers of the testes seen in the sagittal plane may differ in the same individual according to the shape of the segment. This was discovered in *D. lasheyi*, which possesses two types of gravid segments: squarish and elongate. In one of the squarish segments there are about 10, in the sagittal plane, and in the elongate segments 17 testes. It seems that the size of the segment has no effect on the number of testes. In *Diphyllobothrium scoticum*, for example, where the variations in size of the segments are enormous, but the shape is the same, the number of testes in the sagittal plane of the small and the large segments is the same.

The longitudinal muscular coat, examined in transverse section, and its relation to the transverse and dorso-ventral muscles also gives very clear specific differentiation. The thickness of the longitudinal muscular coat and the arrangements of the muscular bundles are characteristic for each species. The numerical differences in the thickness of the muscular coat have been given in Table No. 2. The morphological differences are shown in Plate 11, figs. 10–18.

Examination of the musculature has been made in transverse sections of the hinder part of the segment, between the ovary and the first uterine coils. This part of the segment is not affected by such factors as the pressure of the uterus filled with eggs or histological changes of the ovary, which may interfere with or alter the position of the muscles. The relation of the transverse musculature to the longitudinal is also different in many cases (Pl. 11, figs. 10–18). The transverse musculature in *D. quadratum* is so feebly developed that the separate muscle-fibres might be overlooked in the serial sections. A similar feeble development of the transverse musculature occurs in *D. mobile*, *D. wilsoni*, and *D. lasheyi*, although in these the single muscle-fibres are much more distinct. In the rest of the species, namely, *D. scoticum*, *Baylisia baylisi*, and *Baylisiella tecta*, the transverse and longitudinal muscular coats are very powerfully developed. Moreover, the longitudinal muscles in *B. tecta* are very characteristic.

In *Glandicephalus antarcticus* and *Diphyllobothrium perfoliatum* the transverse and the dorso-ventral muscular system forms a kind of network containing the longitudinal muscular fibres in its meshes. Because of the similarities in the musculature of these species, together with a few more points of resemblance in their anatomy, *D. perfoliatum* has here been transferred to the genus *Glandicephalus* Fuhrmann (1920).

SYSTEMATIC NOTES

1. ***DIPHYLLOBOTHRIUM*** Cobbold (1858)

This genus is represented in the Antarctic seals by five species.

Diphyllobothrium lashleyi (Leiper & Atkinson, 1914)

[Pl. 10, fig. 1; Pl. 11, fig. 10; Pl. 12, figs. 19–24]

Dibothriocephalus lashleyi Leiper & Atkinson, 1914.
Diphyllobothrium lashleyi Meggitt, 1924.
Dibothriocephalus archeri Leiper & Atkinson, 1914.

Diphyllobothrium archeri Meggitt, 1924.

Host: Weddell seal (*Leptonychotes weddelli*).

Locality: Debenham Islands; Deception Island; Melchior Archipelago.

This tapeworm has been found in large numbers in the intestine of seven Weddell seals. Leiper & Atkinson (1914) give its maximum length as 4 cm. and Johnston (1937) 22 mm. The variation in the length of the body as shown by the new material is much greater, from 4 cm. to 19·5 cm. The width is constant at about 3 mm.

The segments are not overlapping and are variable in shape. Those in front are squarish with curved lateral edges; those in the hinder part of the body become elongate. Both kinds of segment may be fully gravid. The size of the first squarish segment bearing eggs is, in mounted specimens, 1 mm. in length and 2 mm. in width. The elongate segments are about 7 mm. in length and 3 mm. in width. The terminal segment is usually slightly tapering and rounded at the end.

The surface of the body in preserved specimens bears transverse furrows, caused probably by the fixative.

The parenchyma is very loose and delicate, and mounted specimens are very transparent, showing the internal structure.

The neck is well developed in fully extended specimens and marked off from the rest of the body. In specimens slightly contracted it is not distinguishable. As a consequence it varies from 450 μ to 2·5 mm. in length.

The scolex, sharply marked off from the body, is also variable in shape; it is globular or oval and possesses internal grandular cells, though this was not previously known. The size of the scolex in mounted specimens is from 1 mm. to 1·5 mm. in length and 0·9 mm. to 1·3 mm. in width.

The genital openings are median, except the uterine pores which alternate in an irregular manner. The genital atrium is surrounded with strongly developed papillae.

In optical view in whole preparations the cirrus-sac appears to be spherical. In sagittal section its length is about 200 μ and the height (antero-posterior) about 93 μ. The cirrus of the specimens examined was usually protruded. The cuticle of the area around the male genital pore is provided with radiating ridges. In the segments examined the vesicula seminalis is in a straight line with the cirrus-sac or inclined to it at a slight angle, and in sagittal section it is about 69 μ long and 55 μ wide, with walls about 17 μ thick.

The testes are arranged in a single layer, about 60 on each side of the segment. They are about 53 μ to 93 μ in diameter. In the squarish segments there are, in transverse section, 2–6 testes each side, and, in sagittal section, 10 testes. In the elongate segments the number of testes in transverse section is 3 on each side and in sagittal, 15–17.

The uterine opening is situated about 116 μ from the cirrus-sac. The uterus forms compact, though not very distinct, coils, and in the elongate segments is club-shaped, tapering posteriorly, and is irregular in outline. In the squarish proglottids the uterus is confluent with the cirrus-sac, reaching its level and alternating with it to its right or left side rather irregularly.

The vagina and the male pore open side by side into the common genital atrium.

The ovary has a compact or reticular structure. It differs with the shape of the

PLATE 12, FIGS. 19–24

(*For list of abbreviations see Plate* 10)

Diphyllobothrium lashleyi from Weddell seal

FIG. 19. Scolex.

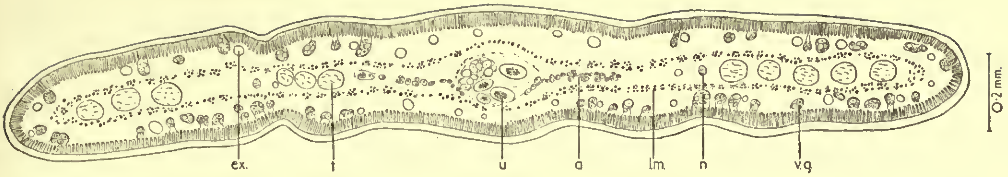
FIG. 20. Gravid, not fully shaped segment.

FIG. 21. Gravid, fully developed elongate segment.

FIG. 22. Transverse section of segment.

FIG. 23. Sagittal section of segment.

FIG. 24. Sagittal section of scolex, showing cephalic glands.



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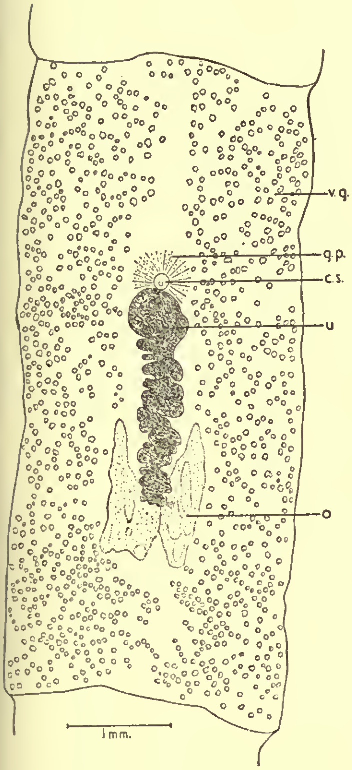

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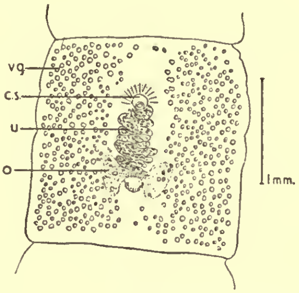

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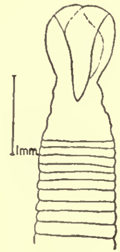

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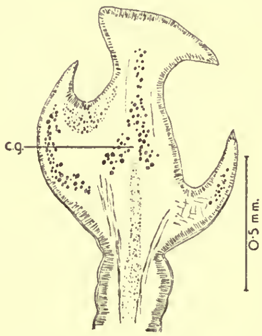

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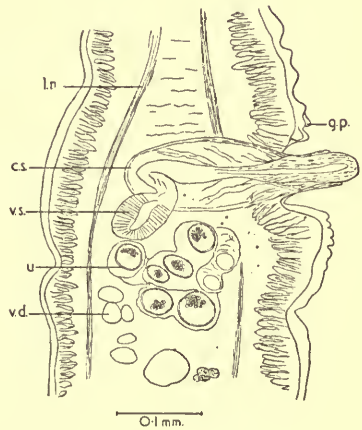

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FIGS. 19–24

segment. In the squarish segment it is more compactly built and oval in shape; in the elongate segments its structure is reticular and more diffuse.

The eggs are 53–56 $\mu \times$ 40–44 μ.

The vitelline glands, composed of large cells, are irregular with rounded lobes. They are sometimes slightly confluent in the anterior parts of the segment and much more so in the posterior region. There is an area free from vitelline glands around the genital complex. The products of the glands are collected in special ducts running through the cortical parenchyma. It seems that there occur additional collectors, transferring the yolk to the main yolk reservoir which is situated in the central part of the segment below the uterus. The reservoir is filled with large yolk cells, olive-greenish in colour. The size of the vitelline glands is 33 μ to 50 μ in diameter.

The longitudinal muscles form a coat, 20 μ thick in transverse section, composed of irregularly distributed bundles. The dorso-ventral musculature is feebly developed.

The excretory system consists of two main stems in the medullary parenchyma and some 28 vessels occurring in the cortical part of the segment, as seen in transverse section.

Leiper & Atkinson (1914) described *D. archeri* from the Weddell seal as a separate species. Comparison of the type specimens of *D. archeri* and *D. lashleyi* with the new material leads to the belief that *D. archeri* is a synonym of *D. lashleyi*. Both authors dealt with specimens not fully developed and having squarish segments, but the anatomical features of the two species, as seen in serial sections of the type specimens, are closely similar. The structure of the longitudinal muscles, cirrus-sac, and the number and arrangements of testes are identical.

Diphyllobothrium mobile (Rennie & Reid, 1912)

[Pl. 10, fig. 2; Pl. 11, fig. 11; Pl. 13, figs. 25–31]

Dibothriocephalus mobilis Rennie & Reid, 1912.
Diphyllobothrium mobile Meggitt, 1924.
Diphyllobothrium wilsoni Railliet & Henry, 1912.
Dibothriocephalus coatsi Leiper & Atkinson, 1914 (*nec* Rennie & Reid, 1912).

Host: Weddell seal (*Leptonychotes weddelli*).
Locality: Debenham Islands.

This species is recorded from seven Weddell seals, twice in company with *Glandicephalus perfoliatus*. The infection was in most cases a mass infection.

The length of the body of the specimens examined varied from 2·3 mm. to 14 mm., and the width from 345 μ to 510 μ.

The strobila is composed of about 14 segments, which in the anterior part of the strobila are wider than they are long. The terminal segment is usually oval.[1]

The scolex is 675 μ–825 μ in length and 345 μ–510 μ in width. Longitudinal serial sections show that it contains glandular tissue.

The neck is little more than an unsegmented part of the scolex, 300 μ in length and 495 μ in width.

[1] Beside the normally-developed segments, one abnormal strobila has been found in the writer's material. In it, the segments are split into two parts. The left-hand portion forms a kind of cul-de-sac and possesses testes and vitelline glands. The right part, which is a continuation of the strobila, contains eggs. (Pl. 13, fig. 25.)

The genital rudiments occur in the immediate vicinity of the scolex. The specimens of 2·3 mm. in length have distinctly visible genital anlagen and well-separated testes.

The length of the cirrus-sac, measured in sagittal section, is about 112 μ and its height 66 μ. Some very thin muscular fibres attach the proximal part of the cirrus-sac to the dorsal wall of the segment.

The vesicula seminalis measures, in sagittal section, about 83 μ by 15 μ; its walls are about 10 μ thick and it is in a straight line with the cirrus-sac.

The testes seem to occur only in the anterior part of the segment and are from 22 to 44 in number. There are 5 testes on each side in the transverse, and 6 to 7 in the sagittal, sections of the segment. They are 66 μ to 99 μ in diameter.

The uterine openings alternate irregularly. The uterus forms a compact mass of coils. In the anterior part of the body it is situated below the cirrus-sac, and in segments in the hinder part of the strobila its coils surround the male copulatory organ.

The vagina opens into the common genital opening in the vicinity of the male opening.

The ovary forms two more or less elongate-oval wings.

The eggs measure 56–60 μ by 40–43 μ.

The vitelline glands, about 33 μ in diameter, are arranged in two separate lateral fields in each segment. A narrow transverse space free of vitelline glands is distinctly visible in the anterior part of the segment in whole preparations as well as in serial sections.

The longitudinal musculature is very feebly developed. It forms a coat about 4 μ thick, composed of single, barely visible, fibres.

The excretory system has not been detected, probably owing to contraction due to the fixative.

Diphyllobothrium quadratum (Linstow, 1892)

[Pl. 10, fig. 3; Pl. 11, fig. 12; Pl. 14, figs. 32–36]

Bothriocephalus quadratus Linstow, 1892.
Dibothriocephalus quadratus Zschokke, 1903.
Diphyllobothrium quadratum Railliet & Henry, 1912.
Cordicephalus quadratus Ward, McLeod & Stewart, 1947.
Dibothriocephalus coatsi Rennie & Reid, 1912.
Bothriocephalus coatsi Fuhrmann, 1920.
Dibothriocephalus resimum Railliet & Henry, 1912.

Host: Leopard seal (*Hydrurga leptonyx*).

Locality: Galindez Island, Argentine Islands; Debenham Islands; Horseshoe Island and Sandefjord Harbour, Coronation Island.

This species is recorded from five Leopard seals, some of which were very heavily infested.

The length of the body is from 4 to 12 cm. and the width about 4·5 mm. The specimens obtained from the mass infested hosts averaged about 4 cm. in length. In horizontal serial sections the lateral margins of the body seem to have a villous character.

The segments are square, about 1·5 mm. long and 1 to 4·5 mm. in width. Their lateral edges in the hinder part of the strobila are slightly convex. The terminal segment is oval.

PLATE 13, FIGS. 25–31

(*For list of abbreviations see Plate* 10)

Diphyllobothrium mobile from Weddell seal

FIG. 25. Malformation of strobila.

FIG. 26. Young specimen with genital anlagen.

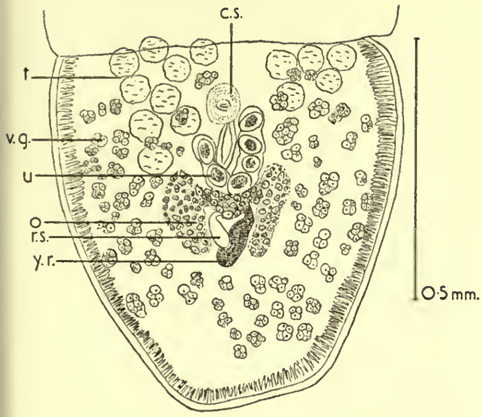
FIG. 27 (*a*). Sagittal section of scolex, showing glandular tissue. (*b*) Glandular cells enlarged.

FIG. 28. Terminal gravid segment.

FIG. 29. Transverse section of segment.

FIG. 30. Sagittal section of segment, showing terminal part of uterus.

FIG. 31. Sagittal section of male and female openings.



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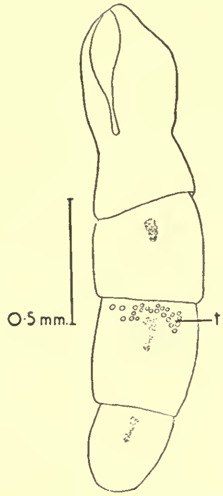

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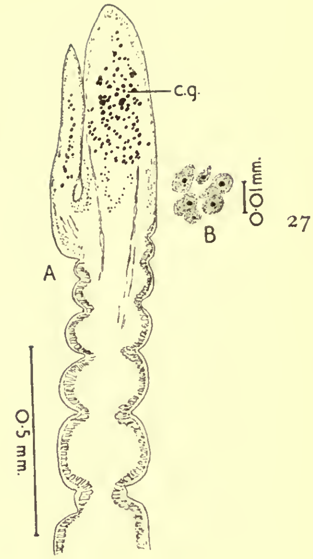

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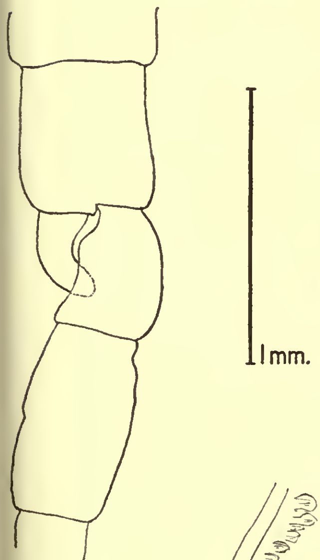

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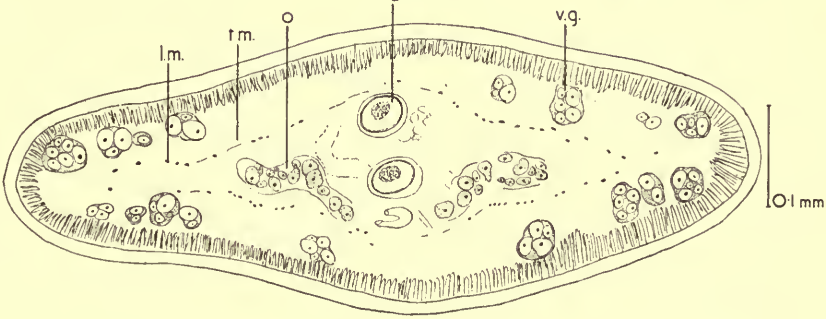

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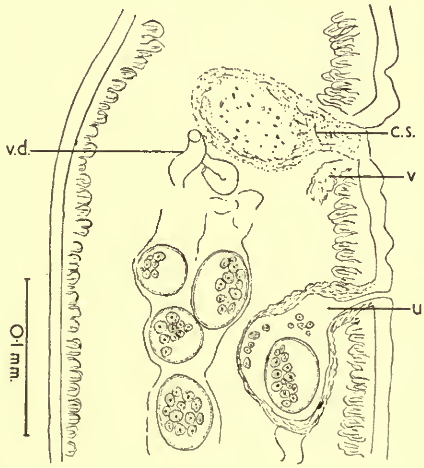

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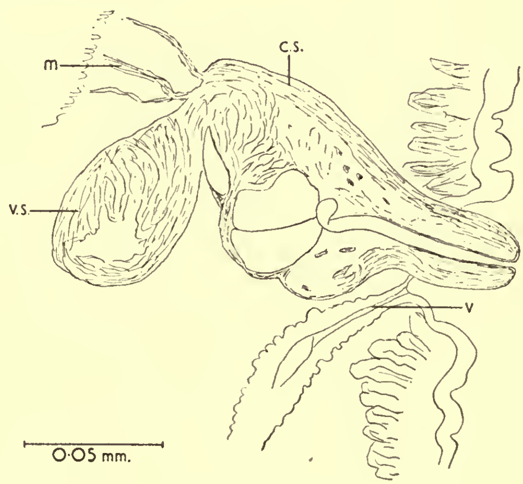

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Figs. 25–31

PLATE 14, FIGS. 32–36

(*For list of abbreviations see Plate* 10)

Diphyllobothrium quadratum from Leopard seal

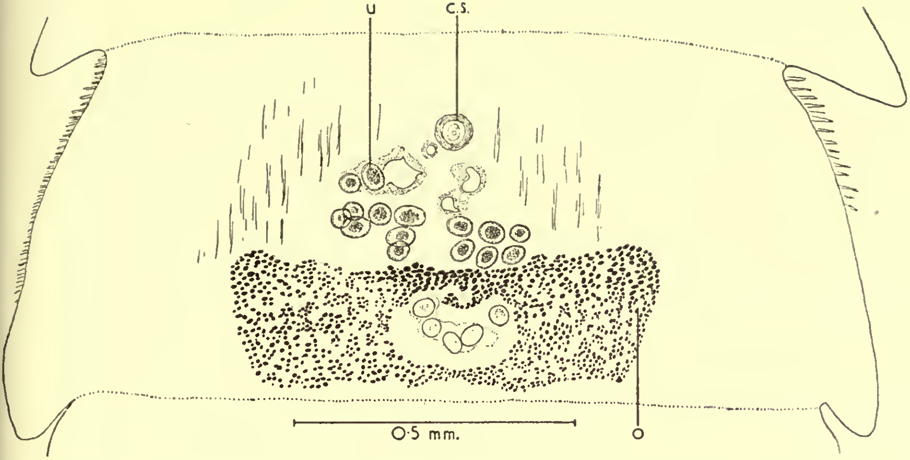
FIG. 32. Scolex.

FIG. 33. Gravid segment.

FIG. 34. Horizontal section of segment, showing structure of ovary.

FIG. 35. Transverse section of segment.

FIG. 36. Sagittal section of segment.



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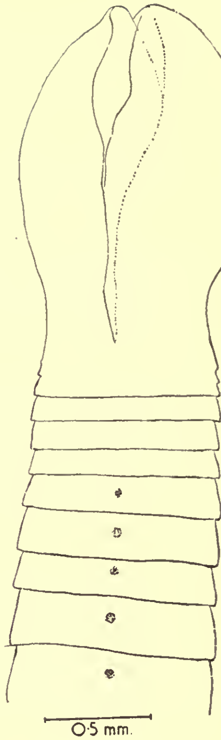

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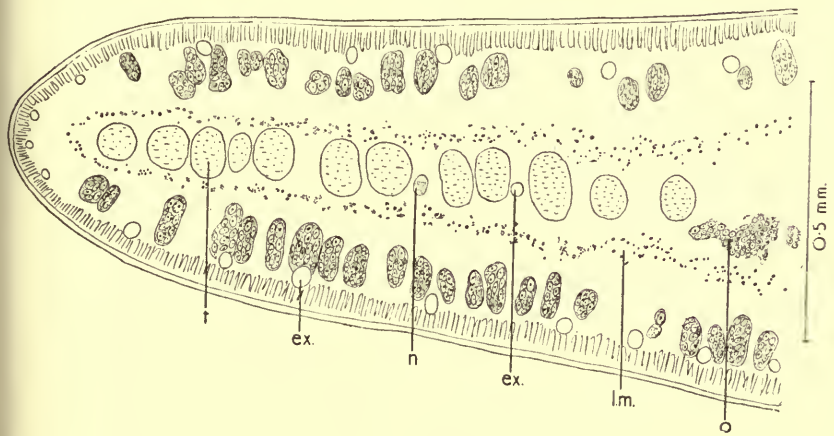

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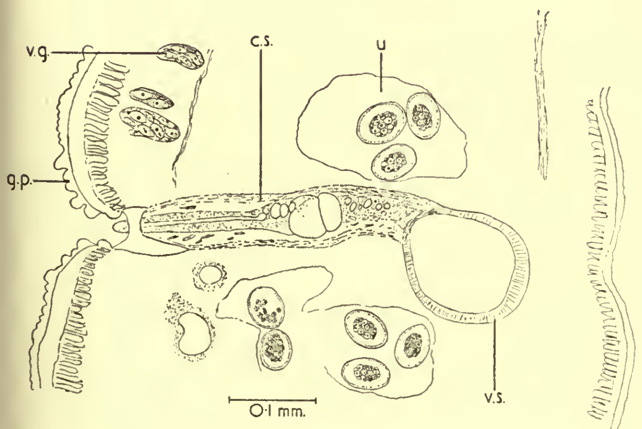

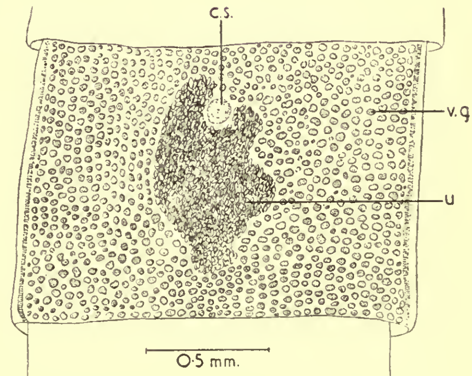

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Figs. 32–36

The scolex of the mounted specimens is 1 to 1·8 mm. in length and 960 μ to 1·4 mm. in width, more or less ovoid in shape and possesses internal glandular tissue.

The neck although short is recognizable and measures from about 450 μ to 1·5 mm. in length and from 587 to 870 μ in width.

The genital rudiments occur in the segment next behind the neck. In whole preparations the cirrus-sac appears to be spherical; in sagittal section its length is about 300 μ and height 60 μ.

The vesicula seminalis is connected with the cirrus-sac almost along the same axis and is 120 μ in length and 105 μ in width. The walls are about 17 μ thick. The almost spherical shape of the organ is sometimes rendered more or less irregular, probably by the fixative used.

There are about 340 testes in each segment, 170 on each side and confluent in its anterior part. They are arranged in a single layer, though this is not very regular in some cases, probably owing to contraction. This was observed in the small 4 cm. long specimens, where some of the testes were arranged in two planes. There are 12 to 16 testes on each side in the transverse, and 12 to 16 in the sagittal, section. They are not very regular in shape and measure about 65 μ by 78 μ.

The vas deferens is situated dorsally in the segment and forms numerous coils.

The uterine openings alternate irregularly. In the hinder region of the strobila the uterus is converted into an irregular sac filled with eggs. The anterior part of the uterus surrounds the cirrus-sac which, in the gravid posterior segments, is hardly visible.

The ovary forms two wings, which surround the lower coils of the uterus. The thin-shelled and operculate eggs are 56 μ by 43 μ.

The vitelline glands are very numerous, thickly arranged, irregularly lobed, and measure 50 μ by 33 μ. They obscure all other organs of the genital complex except the uterus and the cirrus-sac.

The longitudinal muscles, not very well developed, form a coat about 33 μ thick. They are composed of single bundles of fibres.

The transverse and dorso-ventral musculature is composed of single fibres running in these two planes.

The excretory system comprises two main vessels in the medullary parenchyma and about 34 trunks in the cortical part of the segment in transverse section.

Diphyllobothrium scoticum (Rennie & Reid, 1912)

[PL. 10, FIG. 4; PL. 11, FIG. 13; PL. 15, FIGS. 37–43]

Dibothriocephalus scoticus Rennie & Reid, 1912.
Diphyllobothrium scoticum Meggitt, 1924.
Dibothriocephalus pygoscelis Rennie & Reid, 1912.
Host: Leopard seal (*Hydrurga leptonyx*).[1]
Locality: Debenham Islands.

This species has been found in four Leopard seals. The number of worms per host varied from 2 to 14.

[1] Baylis (in Hamilton, 1934) assigned to *Diphyllobothrium scoticum* some Cestodes from the intestine of *Otaria byronia*, but the identification was only provisional and has not yet been confirmed.

The body is much longer than recorded by Fuhrmann (1920) and Johnston (1937) and ranges in the specimens examined from 52 cm. to 130 cm., with a corresponding width of 0·5 cm. to 1·8 cm. The elliptical scolex is about 3·5 mm. in length and 2 mm. in width. No glandular tissue has been found in this organ.

The neck is about 495 μ in length and 825 μ in width. The figures for scolex and neck have been taken from a mounted specimen 52 cm. long.

The segments are shorter than wide and have convex lateral edges. They are tapering in the posterior part of the body, and the terminal segment in small specimens is ovoid. The posterior lateral edge of the segment seems to have a semicircular thickening (Pl. 15, fig. 43). The gravid segments are 5 to 8 mm. in length and 1·5 cm. to 1·8 cm. in width.

The genital rudiments occur in the first segment behind the neck. The male genital openings are surrounded by numerous papillae, radially arranged, and are sometimes bordered with a semi-lunar furrow.

In sagittal section the cirrus-sac measures about 231 μ in length and 142 μ in height. In the vicinity of the cirrus-sac, plainly visible in the sagittal section, occur spherical cells, probably of a glandular character.

The vesicula seminalis is situated in the same main axis, as a continuation of the cirrus-sac. It is about 285 μ in length and 180 μ in width, with walls about 17 μ thick.

The vas deferens runs dorsally in numerous coils.

There are about 600 testes, disposed in two separate fields about 300 on each side, arranged in a single layer and measure about 150–210 μ by 150 μ; they are not confluent in the anterior part of the segment. The number of testes in sagittal section amounts to 25. It seems that there is no difference in the number of testes in sagittal section as between the large and the small gravid specimens. The number of testes counted in transverse section amounts to 14–15 on each side.

The uterine openings alternate irregularly, and are situated in a transverse groove. The terminal part of the uterus is modified to form a thick-walled pocket, lined with a villous tissue. This modification of the terminal uterine duct is typical for the species. The uterus is not of a 'rosette' type but forms spiral coils, more or less distinct, 5–12 in number on each side.

The ovary is reticular and irregularly palm-shaped. The eggs, some provided with a boss, are 76–79 μ by 56 μ.

The vitelline glands, composed of small cells, are fairly large, about 60–105 μ in diameter. They are confluent in the anterior part of the segment, leaving a free area around the genital opening.

The longitudinal, transverse, and dorso-ventral musculature is very well developed. The longitudinal muscles form a coat 150 μ thick measured in transverse section, composed of numerous fibres, collected in not very distinct bundles. They are thickly arranged in the upper parts of the muscular coat, gradually becoming less dense towards the middle of the segment.

The excretory system consists of 2, not always distinctly visible, trunks in the medullary parenchyma and about 20 in the cortical parenchyma. It is, however, not always possible to be sure of the number of cortical excretory vessels as the vessels may contract as a result of fixation and may not be distinct in serial sections.

PLATE 15, FIGS. 37–43

(*For list of abbreviations see Plate* 10)

Diphyllobothrium scoticum from Leopard seal

FIG. 37. Gravid segment of small specimen.

FIG. 38. Modification of terminal part of uterus, seen in transverse section.

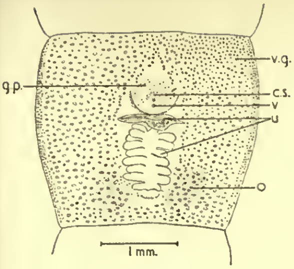
FIG. 39. Scolex.

FIG. 40. Gravid segment of large specimen. Part of cortical parenchyma has been removed, showing distribution of testes and terminal modification of uterus.

FIG. 41. Transverse section of segment.

FIG. 42. Sagittal section of segment with male and female openings.

FIG. 43. Outline of posterior edges of segment, in sagittal section.



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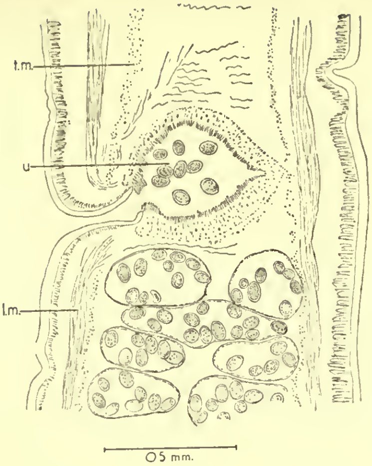

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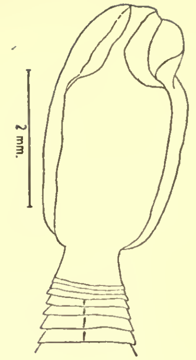

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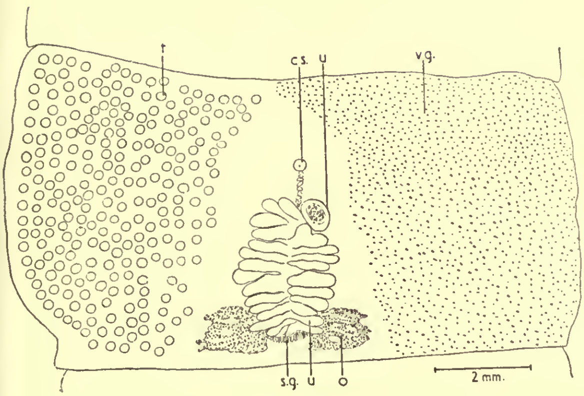

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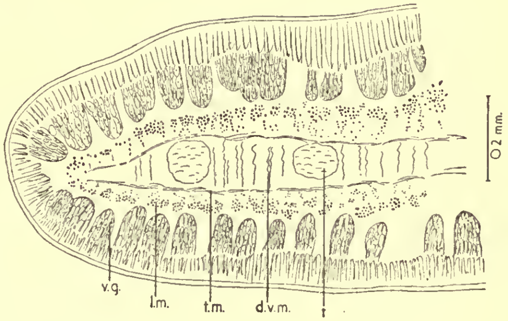

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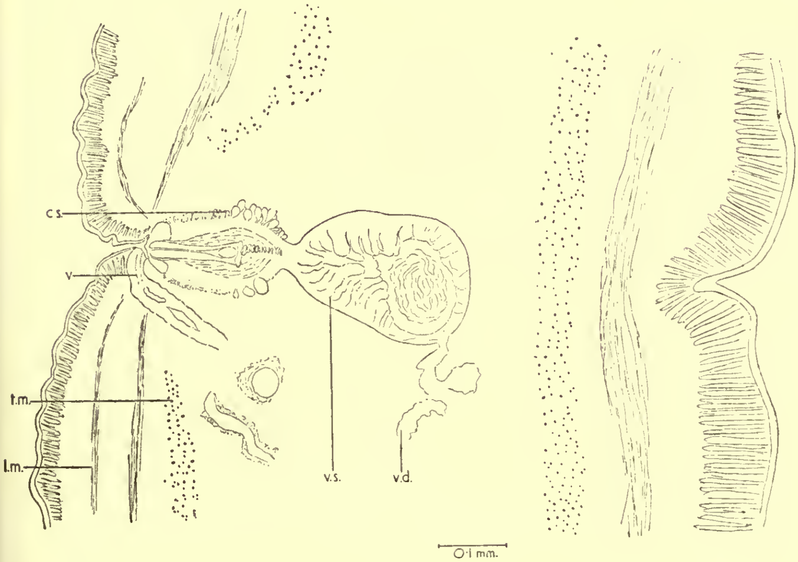

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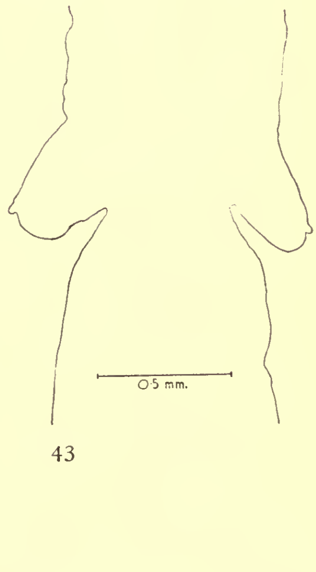

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FIGS. 37–43

Diphyllobothrium wilsoni (Shipley, 1907)

[PL. 10, FIG. 5; PL. 11, FIG. 14; PL. 16, FIGS. 44–50]

Dibothriocephalus wilsoni Shipley, 1907.
Dibothriocephalus scotti Shipley, 1907.
Diphyllobothrium scotti Meggitt, 1924.
Dibothriocephalus mobilis Leiper & Atkinson, 1915 (*nec* Rennie & Reid, 1912).

Host: Weddell seal (*Leptonychotes weddelli*) and Leopard seal (*Hydrurga leptonyx*).

Locality: Deception Island; Beascochea Bay; Debenham Islands; Melchior Archipelago; Argentine Is. (Galindez I.) and South Sandwich.

The species was found in eight Weddell seals and six Leopard seals.

The length of the body varies from about 1 cm. to 5 cm. with a maximum width of 3 mm.

The scolex is variable in size and shape, probably the result of contraction due to fixation; its length is about 825 μ and the width from 450 μ to 1 mm. The presence of glandular tissue in the scolex has been confirmed, using Ehrlich's haematoxylin and erythrosin.

The neck is very short and often impossible to distinguish, 375 μ in length and about 240 μ in width.

The first segments are shorter than wide, becoming gradually squarish, and then longer than wide. The terminal segment is usually oval or elongate-oval.

The genital rudiments occur in the first segment behind the scolex.

The cirrus-sac is 106–165 μ long and 83–99 μ high in sagittal section. It is attached in its hinder part, with numerous well-developed muscular fibres, to the dorsal wall of the segment. These structures are plainly visible in a sagittal section 10 μ thick. The contracted cirrus seems to be coiled spirally. When everted the cirrus is about 44 μ to 59 μ in length.

The vesicula seminalis is about 92 μ in length and 56 μ in width, with the walls about 20 μ thick.

The vas deferens, filled with sperm, runs dorsally and is irregularly coiled.

There are about 150 testes, 75 on each side of the segment, arranged in a single layer and very closely distributed. They are confluent in the anterior part of the segment, irregular in shape, with slightly lobed outlines. There are 8 testes on each side in the transverse and 6 to 8 in the sagittal section; their dimensions are about 132 μ by 99 μ. Histologically, as compared with other species, the testes seem to be more compact and stain more intensively with Ehrlich's haematoxylin. This may, however, be due to the number of spermatozoa in the testicular tissue absorbing more of the stain.

The uterine openings are irregularly alternating. The uterus forms an irregular spherical sac filled with eggs and surrounds the cirrus-sac on both sides.

The vagina opens close to the male genital opening in the common genital atrium.

The eggs are 50 μ by 40 μ.

The ovary is irregular in outline or kidney-shaped with more or less lobated edges. It is composed of large egg cells.

The vitelline glands, measuring 66 μ by 50 μ, are irregularly spherical and somewhat

amoeboid, very numerous, and strongly developed. They form thick uninterrupted layers from segment to segment, covering all the internal organs, except the uterus.

The longitudinal musculature is not very strongly developed. It forms a coat composed of minute bundles about 17 μ thick in transverse section.

The central, medullary excretory system consists of two main stems not very easily distinguishable. The cortical excretory system possesses approximately 14 stems, fairly large in diameter, running among the vitelline glands.

It seems from a comparison of the small specimens of *D. wilsoni* and the type specimens of *D. scotti*, described by Shipley (1907), with the newly-collected material from the Leopard seal, that *D. scotti* is a synonym of *D. wilsoni*. The comparison in Table 3 of Fuhrmann's data (1920) with the figures recorded from the present material shows that there is practically no difference between the two so-called species, except in the size of the body, and it is this which seems to have misled previous authors. The small, mature specimen of *D. wilsoni* might be considered a dwarf form, caused by mass infection and consequent unfavourable living conditions. In the Leopard seal, where the infection is not so heavy, *D. wilsoni* reaches a relatively large size.

TABLE NO. 3

Comparison of D. wilsoni *and* D. scotti

	Fuhrmann (1920)		*Writer's material*
	D. wilsoni	*D. scotti*	*D. wilsoni*
Body: length	10 mm.	9 cm.	5 cm.
width	1·7 mm.	2 mm.	1·5–3 mm.
Scolex: length	850 μ	500–900 μ	825 μ–1 mm.
width	450 μ	700 μ	450 μ–1 mm.
Neck: length	?	short	375 μ
width	?	?	240 μ
Cirrus-sac: length	140 μ	150 μ	106–165 μ
width	?	?	83–99 μ
Vesicula seminalis, diameter	80 μ	80 μ	92 × 56 μ
No. of testes:			
transverse section	6–9	6	8
sagittal section	6	6–10	6–8
Eggs, diameter	60 × 36 μ	64 × 40 μ	50 × 40 μ
No. of cortical excretory vessels	14	12	14
Thickness of longitudinal muscle-layer	12 μ	14–18 μ	17 μ

2. *GLANDICEPHALUS* Fuhrmann 1920

Glandicephalus antarcticus (Baird, 1853)

[PL. 10, FIG. 6; PL. 11, FIG. 15; PL. 17, FIGS. 51–53]

Bothriocephalus antarcticus Baird, 1853.
Dibothrium antarcticum Diesing, 1863.
Diplogonoporus antarcticus Lühe, 1899.
Dibothriocephalus antarcticus Shipley, 1907.
Diphyllobothrium antarcticum Railliet & Henry, 1912.
Glandicephalus antarcticus Fuhrmann, 1920.

Host: Ross seal (*Ommatophoca rossi*).

PLATE 16, FIGS. 44–50

(*For list of abbreviations see Plate* 10)

Diphyllobothrium wilsoni from Weddell seal

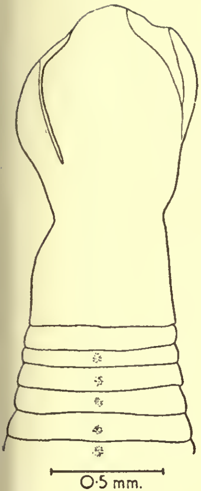
FIGS. 44–46. Scolex in different stages of contraction.

FIG. 47. Gravid segment.

FIG. 48. Terminal segment with double set of gravid genital organs.

FIG. 49. Transverse section of segment.

FIG. 50. Sagittal section of segment.



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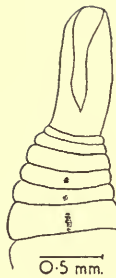

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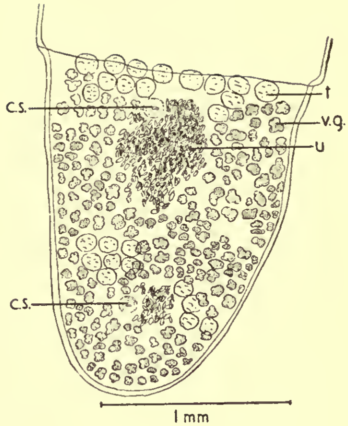

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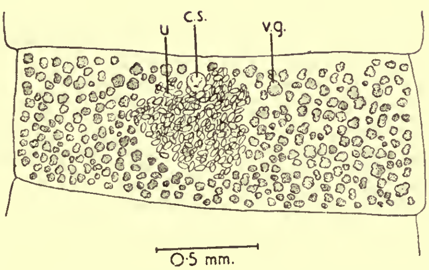

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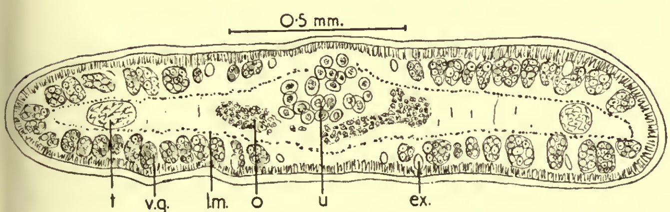

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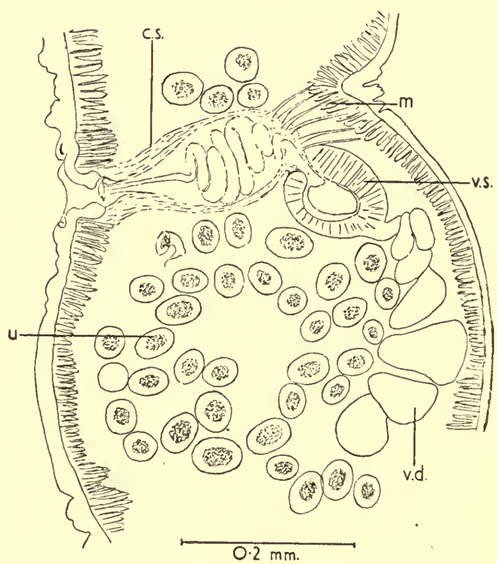

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FIGS. 44–50

PLATE 17, FIGS. 51–53

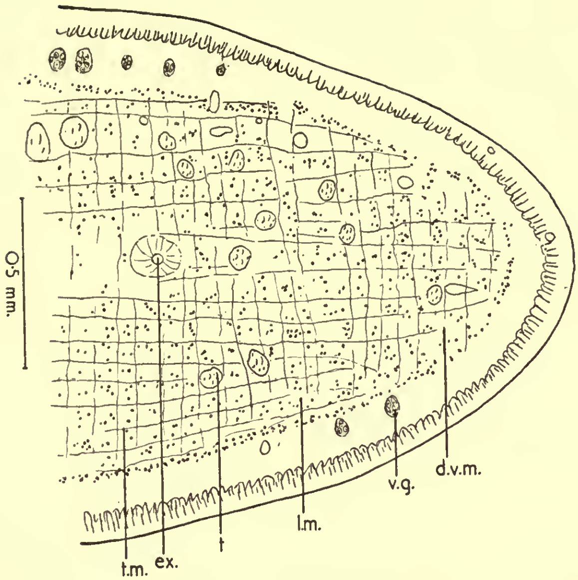
(*For list of abbreviations see Plate* 10)

Glandicephalus antarcticus from Ross seal

FIG. 51. Scolex.

FIG. 52. Sagittal section of several segments.

FIG. 53. Transverse section ot segment.



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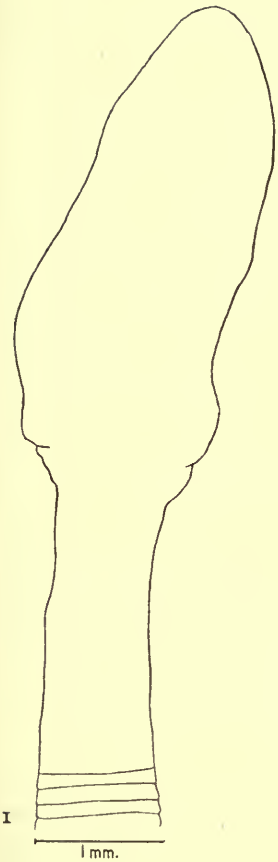

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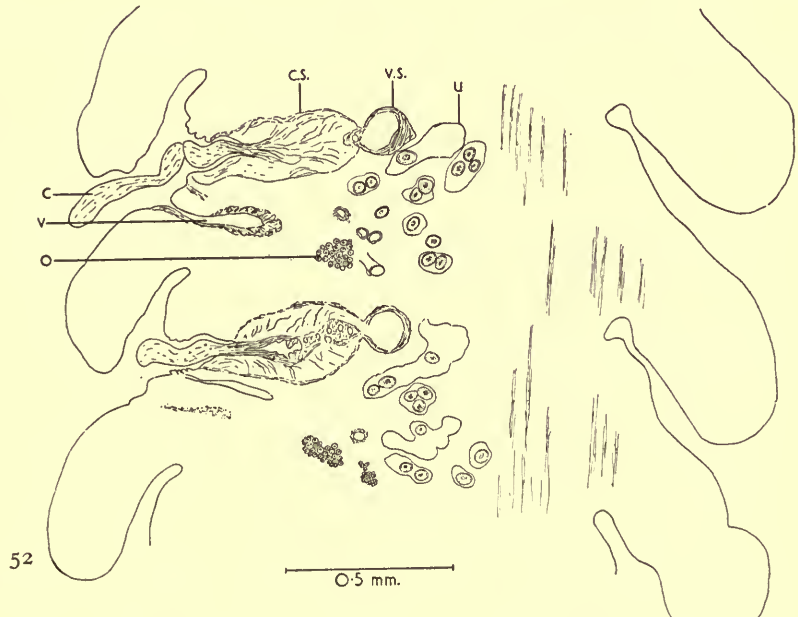

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FIGS. 51–53

This species, described by Baird (1853) and re-described by Fuhrmann (1920), was collected by the Ross's Antarctic Expedition. To give a complete picture of the Pseudophyllidean Cestodes occurring in Antarctic seals, however, the type-specimens have been re-described to show their generic relationship with *Glandicephalus perfoliatus*.

The specimens re-examined were about 10 cm. in length and 7 mm. in width. The strobila is markedly imbricate.

The scolex, 3 mm. in length and 2 mm. in width, is provided with protuberances as depicted by Baird, though these are not distinct in all specimens. No glandular structure was discovered in sagittal serial sections stained with Ehrlich's haematoxylin.

The neck is about 2·35 mm. long and 750 μ in width.

The cirrus-sac, in sagittal section, measured about 462 μ in length and 231 μ in height.

The vesicula seminalis is about 132 μ by 155 μ, with walls about 10 μ thick.

The testes are scattered in the medullary parenchyma and among the longitudinal musculature. They are arranged in irregular layers.

The eggs are 43–50 μ by 33 μ and the vitelline glands are about 40 μ by 50 μ.

The muscular system, as described and depicted by Fuhrmann (1920), is almost identical with that of *G. perfoliatus*. The longitudinal muscular coat is about 450 μ thick.

There are about 30 excretory vessels, counted in the transverse section of the cortical parenchyma.

Glandicephalus perfoliatus (Railliet & Henry, 1912) n. comb.

[Pl. 10, fig. 7; Pl. 11, fig. 16; Pl. 18, figs. 54–59]

Diphyllobothrium perfoliatum Railliet & Henry, 1912.
Dibothriocephalus perfoliatus Fuhrmann, 1920.
Diphyllobothrium clavatum Railliet & Henry, 1912.
Diphyllobothrium rufum Leiper & Atkinson, 1914.

Host: Weddell seal (*Leptonychotes weddelli*).

Locality: Debenham Islands; Stella Creek, Deception Island; Argentine Is. (Galindez I. and Winter I.); Beascochea Bay, Graham Land (Hut Cove, Hope Bay); and Palmer Archipelago (Port Lockroy, Wiencke Island).

This species was collected from thirteen Weddell seals. It occurs usually as a mass infection, mainly in the bile-duct, overhanging into the gut. The specimens examined were at different stages of maturity from 4 mm. to 20 cm. in length. The average length of the body ranges from 12 to 14 cm., and the minimum width is 7 mm.

The strobila is differentiated into two distinct parts: the anterior, ivory white, amounting to about one-third of the total length, and the posterior, yellowish, increasing in width and tapering slightly at a small distance from the posterior end of the body. This differentiation of the strobila has not been observed in specimens of 4 cm. or 5 cm. in length, in which the outline of the body is oval with a well-defined scolex. The surface of the strobila bears, a small distance behind the neck, characteristic strongly developed imbrications formed by the excessive development of the cortical part of the segment.

The scolex is about 3·5 mm. in length, measured in formalin specimens, and 2 mm. in width. No glandular structure has been discovered in longitudinal sections of the organ.

The neck is distinct and ranges from 2·5 mm. to 3 mm. in length and 1 mm. in width.

The segments are very short. The length of a fully gravid proglottid, measured in a sagittal serial section, is about 400 μ. The terminal segment is small and bell-shaped, with a cone at the terminal part of its longitudinal axis. It contains normal genital organs and produces eggs. This peculiar shape of the segment may be the result of fixation.

The genital openings are irregularly alternating and situated on the anterior surface of the imbrications.

The length of the cirrus-sac, measured in a sagittal section, is about 264 μ, and its width 188 μ.

The pear-shaped vesicula seminalis is 148 μ long and 132 μ wide in sagittal section; its walls are about 20 μ thick.

There are about 100 testes in the fully gravid proglottid. They are more or less distributed in a single layer, which is more readily distinguishable in the lateral part of the segment. Near the centre, close to the uterine coils, the testes are arranged in irregular clumps. In transverse section there are about 14 testes on each side, and in the sagittal plane from 3 to 6; they measure 116–172 μ by 73–93 μ.

The vagina opens immediately behind the male pore, slightly obliquely.

The uterine openings are irregularly alternate on the left or right side of cirrus-sac, and the uterus forms an irregular sac with indistinct coils, filled with eggs. These, some of them provided with a boss, are about 60–66 μ by 50 μ.

The ovary comprises two small wings tapering towards the lateral edge of the segment.

The vitelline glands, distributed mainly in the anterior region of the imbrications of the segment, are very irregular in shape and size and measure about 70 μ by 40 μ.

The longitudinal musculature of this species is very unusual and almost identical in structure with that of *G. antarcticus* (Baird). Together with the transverse and dorso-ventral muscular system, it is distributed throughout almost the whole medullary part of the segment. The single bundles of the longitudinal muscular system are separated by the fibres of the dorso-ventral and transverse musculature. Examined in transverse section the two lateral systems form a kind of square which encloses, at its centre, the fibres of the longitudinal muscles. The boundary between the cortical and medullary parenchyma, so characteristic of, and fairly easily distinguishable in, most other species of Pseudophyllidean Cestodes, is not very distinct in *G. perfoliatus*, because of the network formed by the transverse and dorso-ventral musculature, through the meshes of which run the fibres of the longitudinal muscles. In the near vicinity of the testes, or of the excretory vessels, the muscular system is more diffuse.

The central excretory system in the medullary parenchyma is composed of 2 vessels, which run an undulating course through the length of the body and are about 17 μ in diameter. The cortical excretory system seems to be composed of 16 vessels.

PLATE 18, FIGS. 54–59

(*For list of abbreviations see Plate* 10)

Glandicephalus perfoliatus from Weddell seal

FIG. 54. Young immature specimen.

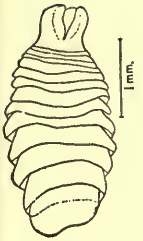
FIG. 55. Young specimen showing differentiation of strobila.

FIG. 56. Portion of strobila showing internal structure, after removal of part of cortical parenchyma.

FIG. 57. Sagittal section of segments with male and female openings.

FIG. 58. Sagittal section of two posterior segments.

FIG. 59. Transverse section of segment, with vitellaria in portion of imbrication.



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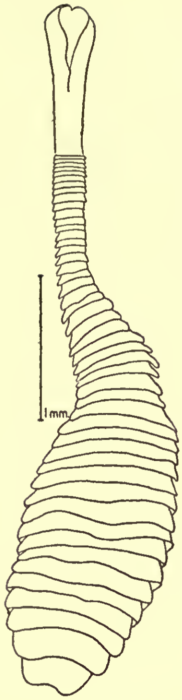

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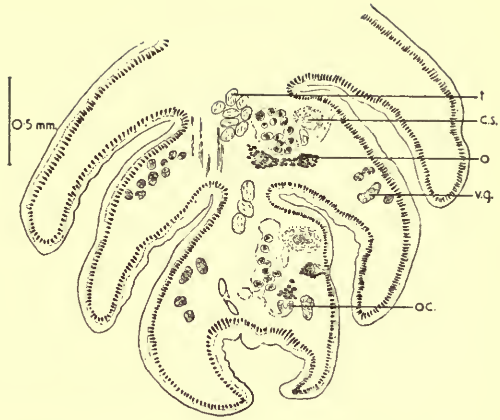

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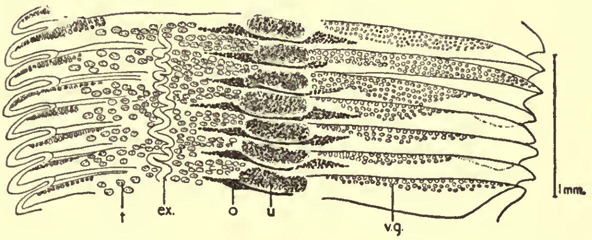

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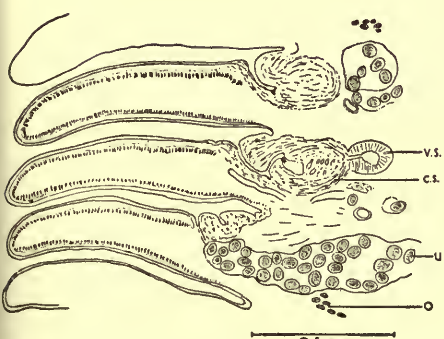

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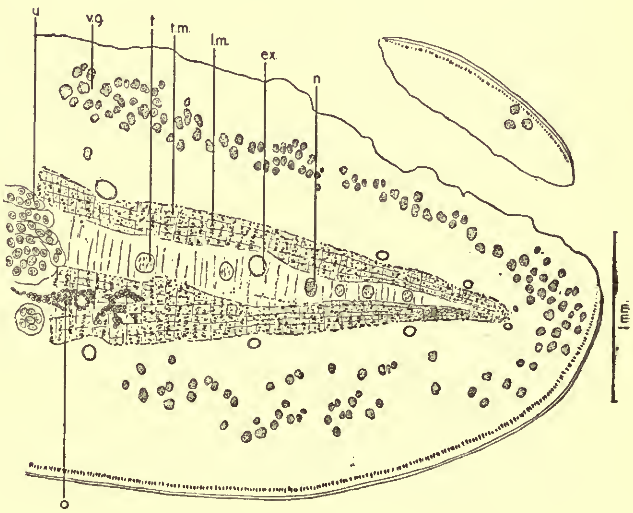

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Figs. 54–59

The two main nerves, 66 μ by 44 μ in transverse section, are situated outside the medullary excretory system.

Comparison of this material with the type specimens of *Glandicephalus antarcticus* (Baird) reveals that, although there is no doubt that there are two distinct species, these have features in common that appear to warrant their being grouped together in a single genus distinct from *Diphyllobothrium*; the name *Glandicephalus* Fuhrmann (1920) is available. It is true that this name was coined by Fuhrmann in consequence of his discovery of glandular tissue in the scolex of *antarcticus* and that no such tissue has been found in the scolex of *perfoliatus*; but this character is not at all diagnostic of *Glandicephalus* and occurs in several species of *Diphyllobothrium*, e.g. *D. lashleyi*, *D. mobile*, and *D. quadratum*. Features common to both *antarcticus* and *perfoliatus*, but not found in any true *Diphyllobothrium*, are as follows: imbrication of the segments (less well developed in the first species); presence of a well-separated neck, and the arrangement of the musculature. In both species the transverse and dorso-ventral muscles form a kind of network spread in the medullary parenchyma, enclosing in the 'meshes' the fibres of the longitudinal muscles. Moreover, the vitelline glands are situated in the anterior region of the imbrications of both species. Finally, they seem to show a host specificity: *G. antarcticus* for *Ommatophoca* and *G. perfoliatus* for *Leptonychotes weddelli*.

Leiper & Atkinson (1914) describe another species from the Weddell seal, namely, *Diphyllobothrium rufum*. Johnston (1937), who examined immature specimens which he thought to be *D. rufum*, was apparently inclined to believe that the species was probably a 'precocious form' of *G. perfoliatus*. Comparison of the type-specimens of *D. rufum* with *G. perfoliatus* reveals that the only differences are in the shorter neck and the presence of a 'notch' in the posterior margin of some of the segments. The neck of *D. rufum*, measured in sagittal section, is over 1 mm. in length. To judge from the published descriptions there would seem to be a difference in egg size also, for Leiper & Atkinson report the eggs of *D. rufum* to be 25 μ in diameter. This, however, appears to be a slip; in the type specimens their dimensions are 59–66 μ by 43–46 μ, which is identical with the size of the eggs in *G. perfoliatus*. Further, there are no differences in the structure of the genital apparatus or of the musculature. *Diphyllobothrium rufum* seems, therefore, to be a synonym of *Glandicephalus perfoliatus*.

3. ***BAYLISIA*** gen. nov.

Diagnosis: Large Cestodes in which the anterior part of the body is cylindrically modified. Scolex with cup-shaped bothria. Normal segmentation not distinct; the body bears pseudosegmentation not corresponding to the individual sets of genital organs.

Genital organs and their openings situated ventrally on both sides of the segment in double sets, regularly alternate in relation to the main axis of the body.

Testes arranged in a single layer. Ovary ramified. Longitudinal muscles forming a thick coat. Excretory system situated in the cortical parenchyma.

Type species: *Baylisia baylisi* sp. nov.

Type host: Crabeater seal (*Lobodon carcinophagus*).

Baylisia baylisi sp. nov.

[Pl. 10, fig. 8; Pl. 11, fig. 17; Pl. 19, figs. 60–68]

Host: Crabeater seal (*Lobodon carcinophagus*).
Locality: Deception Island; Debenham Islands.

This parasite has been found in two Crabeater seals. There were two complete worms, one 35 cm. in length and 1 cm. in width and a second 126 cm. by about 8 mm., together with some fragments of strobila, varying from 15 cm. to 63 cm. in length and from 11 mm. to 15 mm. in width.

The colour in formalin is ivory-white in the anterior part of the body, becoming brownish-grey in the posterior segments. The ivory-white part of the strobila, about 2 cm. in length, is more or less cylindrical.

There are two double furrows running laterally along the body. The central part of the strobila is convex along the main axis, marking the position of the uterus.

The scolex has two cup-shaped bothria, and measures, in the specimen mounted in Canada, balsam about 900 μ long and 1·3 mm. broad.

A neck seems not to be developed since segmentation starts immediately behind the scolex.

The segmentation is very distinct, but apparently does not divide the body into single genital complexes, as happens in other tapeworms. The 'segments' are 2 cm. long and about 1·5 cm. in width, the terminal one being oval.

The genital openings are situated ventrally on a segment in the longitudinal furrows, alternately left and right. There are about 30–40 double genital sets in one 'segment', which alternate in relation to the main axis of the body, being arranged in 'zigzag', in contrast to *Diplogonoporus*, where they occur as two genital sets in the same transverse plane. In *Baylisia baylisi* one set of the genital organs only may be seen in transverse section.

The cirrus-sac measures 750 μ long and 180 μ high in sagittal section. An irregularly coiled ductus ejaculatorius is situated inside the cirrus-sac. A cirrus has not been observed.

The vesicula seminalis is situated slightly laterally but internally to the cirrus-sac, and is 198 μ long and 99 μ wide in sagittal section; its walls are about 33 μ to 50 μ thick. The internal surface of the walls seems to have a villous structure.

Beside the normally developed cirrus-sac mentioned above, one abnormality has been noted. Two cirrus-sacs were joined together, with a common opening, but each with a separate vesicula seminalis (Pl. 20, fig. 65).

In each segment there are about 36 testes arranged in a single layer and flattened antero-posteriorly. The number of testes in transverse section amounts to about 18 on each side, and there is 1 testis in sagittal section. The testes measure 165 μ in diameter in transverse section and 40 μ in the sagittal plane. They are elongate-oval, 116 μ by 40 μ in horizontal section, with the longer axis transverse to the main line of the segment.

The vagina opens into the genital atrium with the male opening and runs ventrally, but is transverse to the terminal part of the uterus.

PLATE 19, FIGS. 60–68

(*For list of abbreviations see Plate* 10)

Baylisia baylisi from Crabeater seal

FIG. 60. Scolex.

FIG. 61. Sagittal section of fused cirrus-sac, with common genital duct and opening.

FIG. 62. Transverse section of part of male and female genital apparatus.

FIG. 63. Transverse section of segment, showing structure of ovary and genital ducts.

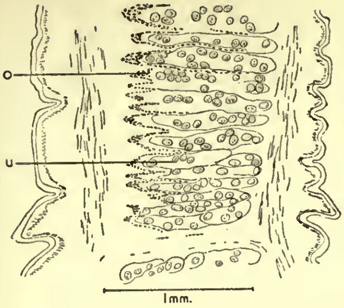
FIG. 64. Sagittal section of part of segment, showing arrangement of ovaries and uterine coils.

FIG. 65. Transverse section of male and female ducts (enlarged).

FIG. 66. Transverse section of segment.

FIG. 67. Sagittal section of segment, showing male copulatory organs.

FIG. 68. Horizontal section of part of strobila, showing arrangement of genital organs.



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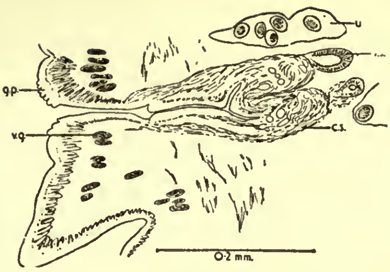

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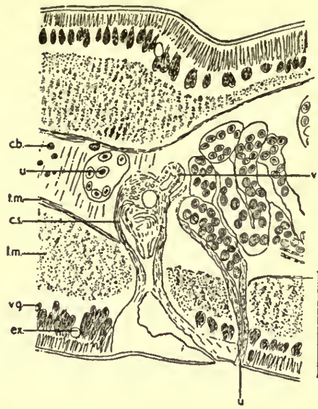

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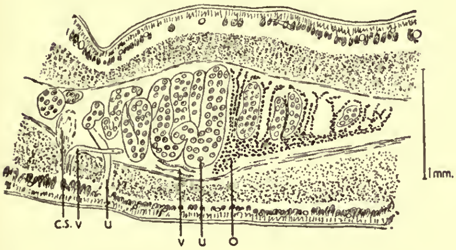

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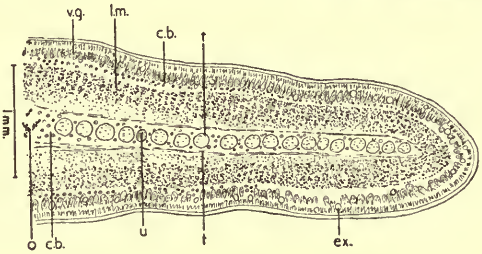

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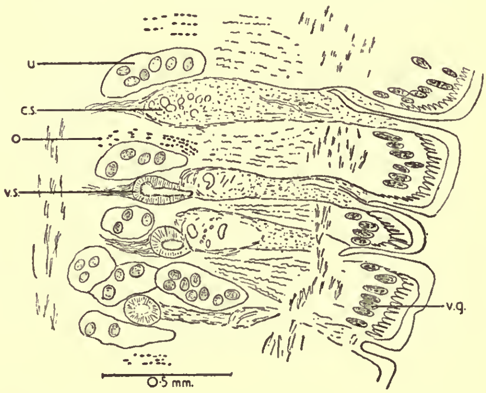

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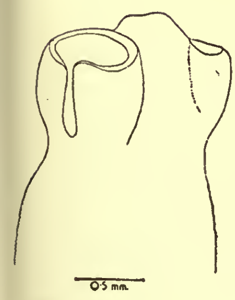

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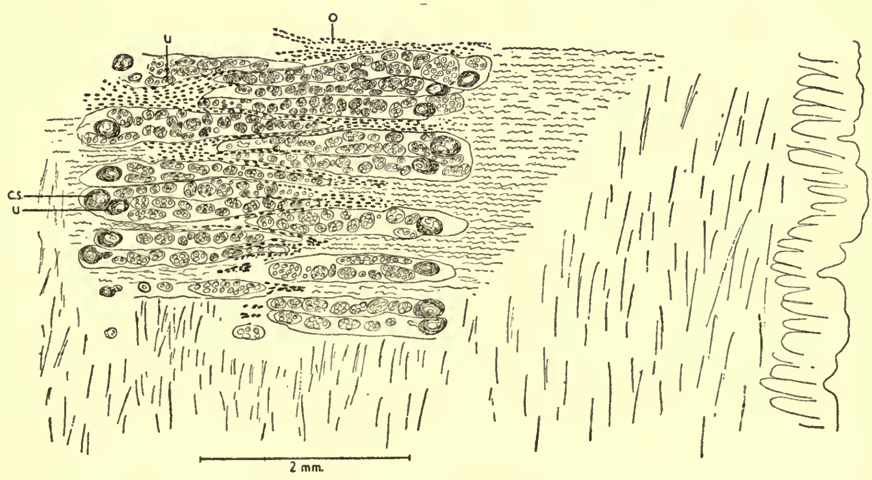

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Figs. 60–68

The uterine openings on both sides are situated nearer the median line than the genital openings and lie posteriorly and obliquely to the cirrus-sac. The uterus itself comprises a few horizontal coils in the central part of the segment.

The ovary is very characteristic and is composed of one solid compact central part, giving off a system of branches and ramifications among the uterine coils; in sagittal section it is V-shaped.

The eggs are 66 μ by 46 μ.

The musculature is very well developed. The longitudinal muscles form, in transverse section, a continuous coat about 450 μ thick, composed of numerous bundles. The transverse muscles are also well developed but the dorso-ventral musculature is much weaker.

The excretory system seems to occur only in the cortical parenchyma, and is composed of about 76 vessels, visible in transverse section. Their transverse diameters differ considerably. This cortical excretory system is situated near the surface of the segment and runs among the vitelline glands.

The vitelline glands, 43 μ by 20 μ, are composed of tiny cells and form a continuous layer, interrupted by the excretory system. They are more or less irregularly elongate in sagittal section, and elongate-oval in the horizontal plane.

'Calcareous' bodies are very numerous, 17 μ by 26 μ in diameter, and occur in the cortical and medullary parenchyma. They have also been noticed among the longitudinal muscles.

4. *BAYLISIELLA* gen. nov.

Diagnosis: Pseudophyllidean Cestodes with the scolex bearing two strongly developed bothria, modified in the anterior part in a foliaceous lamella. The thick strobila, composed of very short and broad segments, is tapering posteriorly. The testes, arranged in two or three layers in the medullary parenchyma, have a tendency to ascend dorsally in relation to the uterus. The longitudinal muscles form, in transverse section, club-shaped or elongately oval bundles, some of them collected in pyramids, separated by the excretory vessels. Excretory system occurs in the cortical parenchyma.

Type species: *Baylisiella tecta* (Linstow).

Type host: Elephant seal (*Macrorhinus leoninus*).

Baylisiella tecta (Linstow, 1892)

[Pl. 10, fig. 9; Pl. 11, fig. 18; Pl. 20, figs. 69–72]

Bothriocephalus tectus Linstow, 1892.
Dibothriocephalus tectus Zschokke, 1903.
Diphyllobothrium tectum Meggitt, 1924.
Cordicephalus tectus Wardle, McLeod, & Stewart, 1947.

Host: Elephant seal (*Macrorhinus leoninus*).
Locality: Bay of Isles, South Georgia.

This species was found in two Elephant seals; there were three entire worms in one host and two in the other, one specimen being headless.

The thick belt-shaped strobila, composed of very short indistinct segments, is 32 cm. in length and 2 cm. in width.

The previous descriptions of Linstow (1892) and Fuhrmann (1920) were based on headless specimens.

The scolex, not previously described, is deeply embedded in the intestinal tissue and very characteristic in shape. It possesses two powerful bothria and a complicated lamellar structure of their upper part, which recalls the scolex of *Pyramicocephalus* Monticelli 1890. The 'cauliflower' lamellar structure seems to give rise to two lateral lamellar flaps and there is a similar differentiation on the top of the scolex. The length of the scolex is 8 mm. and the width 5 mm., and the transverse diameter across the 'flap' is 12 mm.

The neck seems to be very short or not-existent.

The segments are very short, about 165 μ–200 μ in length.

The genital pores are situated in a common recess, provided with numerous papillae.

The cirrus-sac, measured in sagittal section, is about 450 μ in length and 150 μ in height.

The vesicula seminalis, situated in the same axis as the cirrus-sac, is 195 μ in length and 180 μ in width; its walls are about 30 μ thick.

The vas deferens runs dorsally in numerous coils.

The testes are distributed in 2 or 3 layers, some of them ascending almost dorsally to the uterus and close to it. There are about 45 testes on each side in transverse, and 2 or 3 in sagittal, sections. They measure about 136 μ by 86 μ.

The uterine openings are situated a little below the cirrus-sac on the right side. The uterus comprises a few irregular transverse coils.

The vagina opens in the vicinity of the cirrus-sac on its right side.

The ovary is bilobed and elongate.

The eggs with 3 μ thick shells, measure 59–66 μ by 46 μ and are thickened opposite to the operculum.

The vitelline glands, 66 μ by 26 μ, and arranged in a very thick layer, are very numerous, spherical or oval in transverse section. They form a compact mass of glands in the cortical parenchyma.

The excretory system seems to occur in the cortical part of the segment. It is very strongly developed and runs through the longitudinal muscular system with numerous transverse anastomoses. In transverse section about 108 excretory canals have been counted.

The musculature is exceedingly well developed. The longitudinal muscles are collected in large irregular bundles, which, in transverse section, appear club-shaped or elongate-oval. The bundles are often separated into distinct groups between which run excretory canals and dorso-ventral muscle-fibres. The thickness of the longitudinal muscular coat is about 555 μ. There is also a layer of longitudinal muscles situated in the subcuticular region of the segment, externally to the vitelline glands. This additional layer is composed of scattered, rather thick, individual fibres or very small bundles of fibres. The transverse muscles are also very strongly developed.

This species represents a new genus, *Baylisiella*, distinguished from *Bothriocephalus*

PLATE 20, FIGS. 69–72

(*For list of abbreviations see Plate* 10)

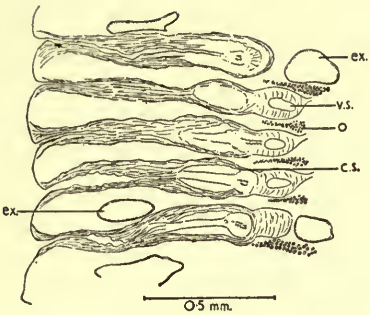
Baylisiella tecta from Elephant seal

FIG. 69. Transverse section of segment.

FIG. 70. Transverse section of male apparatus.

FIG. 71. Sagittal section of segment.

FIG. 72. Scolex.



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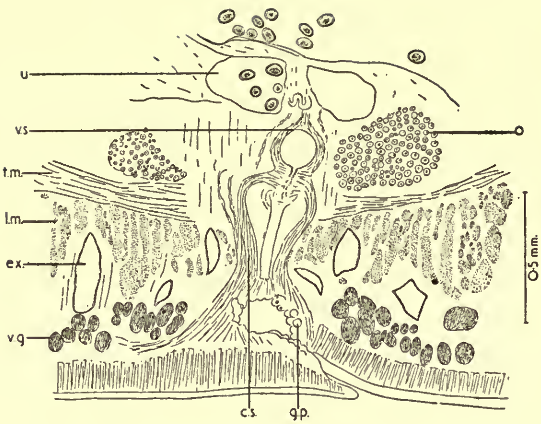

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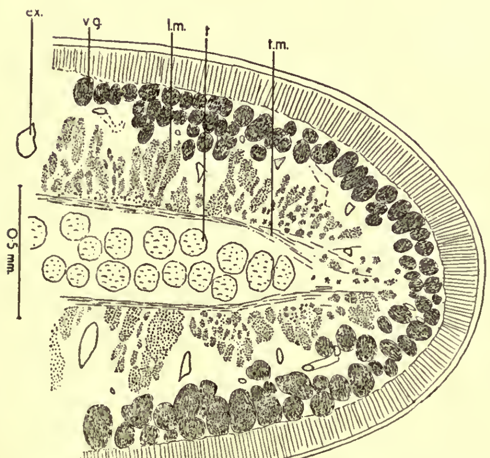

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FIGS. 69–72

and *Diphyllobothrium* by characteristic differences in the structure of the scolex, in the development of the muscles, and in the distribution of the testes.

? ***Diphyllobothrium*** larvae

[PL. 21, FIGS. 74–75]

Host: Weddell seal (*Leptonychotes weddelli*): Leopard seal (*Hydrurga leptonyx*).
Locality: Melchior Archipelago; Debenham Islands; Cooper Bay, South Georgia.

Beside the adult forms enumerated in this paper, juvenile stages have also been discovered in five Weddell seals and in one Leopard seal. The infection bears in some cases a mass character. The identification of these juvenile forms was not possible, because of a complete lack of morphological features. They belong probably to one of the species dealt with here, most likely to *Diphyllobothrium wilsoni* or *D. mobile*.

Based on differences in the scolex, two types of larvae might be distinguished: one with a kind of papillary modification occurring at the edge of the bothria, and another with the typical scolex of *Diphyllobothrium* but with the bothria smooth.

The maximum length of the body of the first type, from the Weddell seal, is about 3 mm. long and about 1 mm. in width, and the second, from the Leopard seal, is about 1·2 mm. in length and 195 μ in width.

? ***Diphyllobothrium*** sp. (larva)

[PL. 21, FIG. 73]

Host: Crabeater seal (*Lobodon carcinophagus*).
Locality: South Sandwich.

This juvenile stage was collected by the *Discovery* on 21 March 1928 from the intestine of a Crabeater seal.

The total length of the body is 7 mm. and the width 480 μ.

The scolex is well separated from the rest of the body and is heart-shaped, tapering anteriorly. Its length is 675 μ and its width 480 μ.

The bothria are well developed.

The unsegmented body has neither genital organs nor their rudiments, making identification impossible.

OCCURRENCE OF THE PARASITE AND ITS RELATIONSHIP TO THE HOST

As already stated, there are nine species of Pseudophyllidean Cestodes known to occur in the Antarctic seals. An analysis of the parasites and their hosts is shown in Table No. 4.

Our knowledge of these parasites is very limited and the present material is merely the tenth collection of this kind. Nevertheless, certain speculations may be justifiably made on the occurrence and the host specificity of these parasites, as well as on their

TABLE No. 4

Composition of Pseudophyllidean Cestodes in the present material

Diphyllobothrium lashleyi (Leiper & Atkinson, 1914)	*Leptonychotes weddelli*
D. mobile (Rennie & Reid, 1912)	,, ,,
D. quadratum (Linstow, 1892)	*Hydrurga leptonyx*
D. scoticum (Rennie & Reid, 1912)	,, ,,
? *D. sp.* (larva)	*Lobodon carcinophagus*
D. wilsoni (Shipley, 1907)	*Leptonychotes weddelli, Hydrurga leptonyx*
Glandicephalus antarcticus (Baird, 1853)	*Ommatophoca rossi*
G. perfoliatus (Railliet & Henry, 1912)	*Leptonychotes weddelli*
Baylisia baylisi gen. nov., spec. nov.	*Lobodon carcinophagus*
Baylisiella tecta (Linstow, 1892) gen. nov.	*Macrorhinus leoninus*

host-relationship. It may be presumed that *Glandicephalus perfoliatus* and *Diphyllobothrium lashleyi* are specific to the Weddell seal, *G. antarcticus* to the Ross seal, and *D. quadratum* and *D. scoticum*[1] to the Leopard seal. The newly-described *Baylisia baylisi* is the first identified Cestode from the Crabeater seal, although unidentified tapeworms have been reported from this host by Railliet & Henry (1912). *Baylisiella tecta* seems to be closely associated with the Elephant seal. Linstow (in Shipley, 1902) identified some Cestodes collected from the Ross seal as belonging to this species, but this identification requires confirmation. The two next species, *Diphyllobothrium mobile* and *D. wilsoni*, are less selective in their hosts, the first occurring in the Weddell and Ross seals, the second in the Leopard and Weddell seals. According to information supplied by Dr. G. C. L. Bertram, who collected the Graham Land material, the most frequently and heavily infested species are the Weddell seal, the Leopard seal, and the Elephant seal. In the Crabeater seal infestation with tapeworms very seldom occurs and the present record is virtually the first.

It is obvious that the nature of the food has an enormous influence on the kind and number of parasites. The Weddell seal eats fish and cephalopods. The food of the Leopard seal is composed of penguins and fish. The food of the Crabeater seal consists of Crustacea, mainly Euphausiids.

These Cestodes occur in specific parts of the gut of the host. *Glandicephalus perfoliatus* infests mainly the bile-duct, overhanging into the lower part of the intestine. It occurs very often as a mass infection, choking the lumen of the bile-duct. *Diphyllobothrium lashleyi, D. mobile, D. quadratum, D. scoticum,* and *D. wilsoni* infest the duodenal part of the gut and *Baylisia baylisi* and *Baylisiella tecta* occur in the rectum. Except for these two and *Diphyllobothrium scoticum,* the rest of the species occur very often as a mass infestation occupying almost all the free surface of the gut.

D. scoticum does not occur in such numbers as the others but makes up for it in the size of the individuals. It is the largest Cestode recorded from the Antarctic seals. *Baylisiella tecta* also is fairly large and is not numerous in the gut.

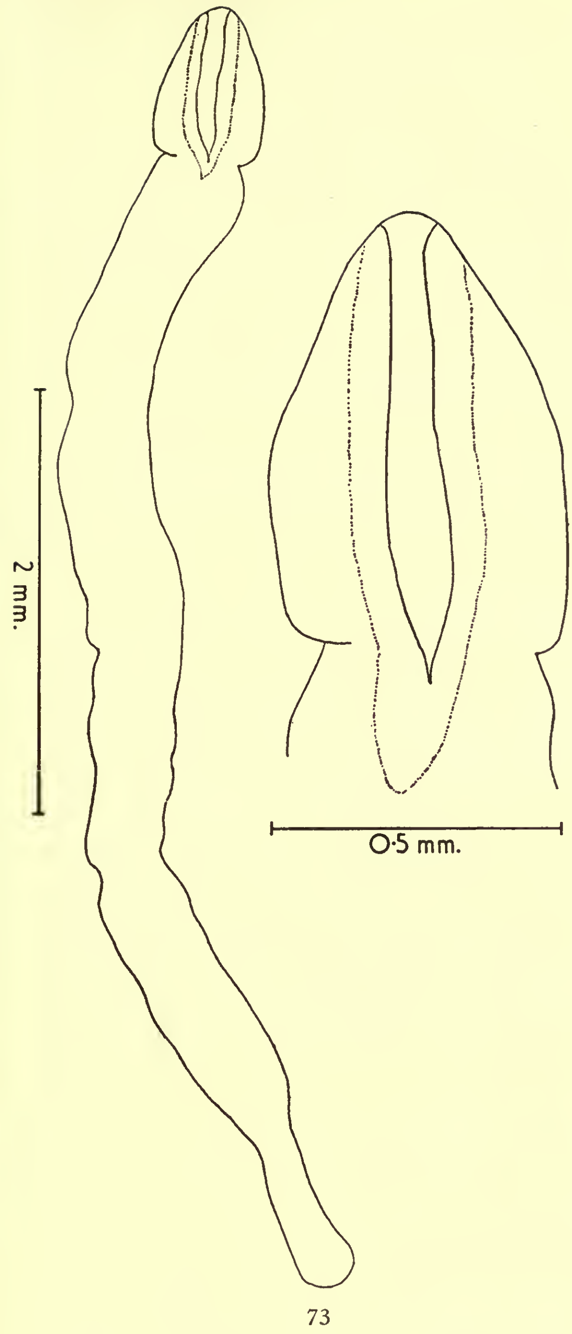
Diphyllobothrium wilsoni and *D. mobile* have been considered by previous authors as dwarfs, and the smallest species of *Diphyllobothrium, D. wilsoni,* is very small, reaching in mass infestation no more than 10 mm. in length. On the other hand, specimens collected from the less heavily infested Leopard seals reach from 5 to 9 cm.

[1] See footnote on p 137.

PLATE 21, FIGS. 73–75

Fig. 73. ? *Diphyllobothrium* sp. from Crabeater seal.

Figs. 74–75. Two types of larvae from Weddell seal.



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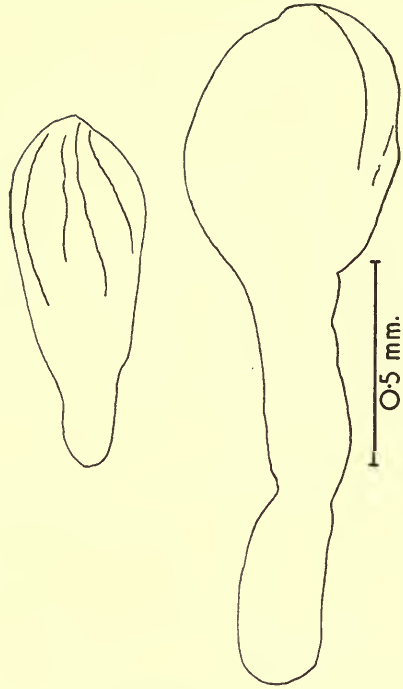

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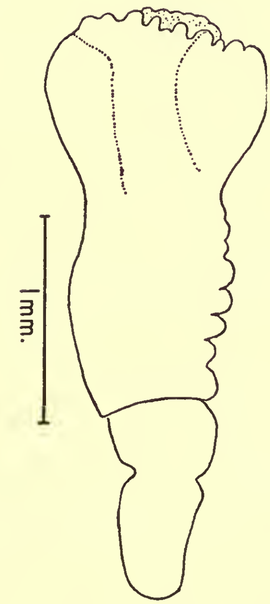

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Figs. 73–75

in length. The larger specimens were considered by Shipley (1907) to be a separate species, *D. scotti*. It is quite probable that further investigation of the Cestodes of Antarctic seals will prove that the small size of *D. mobile* is also caused by the living conditions in mass-infected hosts.

Where a mass infestation occurs one species of Cestode only is invariably present. Usually in the moderately infested hosts the Cestodes may represent more than one species. *Glandicephalus perfoliatus* was recorded in the same host together with *Diphyllobothrium lashleyi*, *D. mobile*, and *D. wilsoni*. The same has been shown for the occurrence of *D. scoticum* with *D. quadratum* and *D. wilsoni* in the same gut.

No pathological changes of the gut have been observed, except in the rectum of the Elephant seal, where *Baylisiella tecta* provokes large nodules, about 3 cm. in diameter. This is caused by the scolex being very deeply embedded in the intestinal wall. Judging from the mass occurrence of parasites in the gut of seals, there must be a high degree of immunity on the part of the host against toxic factors provoked by the parasite.

It seems from the literature that the Pseudophyllidean Cestodes found in the Antarctic seals do not occur in any other species of Pinnipeds.

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PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

THE 'MANIHINE' EXPEDITION TO THE GULF OF AQABA

1948–1949

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ZOOLOGY Vol. 1 No. 8
LONDON : 1952

THE 'MANIHINE' EXPEDITION TO THE GULF OF AQABA 1948–1949

Xnf.

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BULLETIN OF

THE BRITISH MUSEUM (NATURAL HISTORY) Xnf

ZOOLOGY Vol. I, No. 8

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

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Issued August 1952 *Price Twenty-five shillings*

THE 'MANIHINE' EXPEDITION TO THE GULF OF AQABA

I. FOREWORD: STATION LIST AND COLLECTORS' NOTES

DURING the winter of 1948–1949 the motor-yacht *Manihine* was engaged in biological investigations in the Gulf of Aqaba on behalf of the British Museum (Natural History), the work being under the supervision of Mr. N. B. Marshall.

This gulf is of special interest because in it the peculiarities of the Red Sea appear at their most intense. The Red Sea is geologically young with a fauna derived from that of the Arabian Sea and, possibly, the Mediterranean. This immigrant fauna is now completely isolated from the last-mentioned and also partially isolated from the former by reason of the narrowness and shallowness of the connecting passage, the Strait of Bab-el Mandeb. It also finds itself in a region where some, at least, of the ecological conditions are very different. The most noticeable of these ecological differences is to be found in the isohaline and isothermal nature of the water below 200 metres and the complete absence of any cold, deep-water layer. The John Murray Expedition (Seymour Sewell, 1935, *John Murray Exp., Reports*, **1,** 1) recorded temperatures from 21·64 to 21·84° C. at depths of 1,000 to 1,900 metres in the Red Sea, but at similar depths in the Gulf of Aden the temperature was at least 10° C. lower (3·59–11·53° C.). The degree of isolation of the Aqaba fauna is greater than that of any other part of the Red Sea since the passage between the two, the Strait of Tiran, provides only a restricted channel for faunal interchange. The strait is both narrow and shallow, forming a distinct sill, with a greatest depth of less than about 300 metres; on either side of the sill the water deepens rapidly to 1,000 metres and upwards. The hydrological conditions inside the gulf appear to be essentially similar to those in the Red Sea proper, though, as might be expected, salinities are somewhat higher.

In this Bulletin are reports on some of the collections that were brought back. Other reports, including a study of the interchange of heat and water vapour between the surface water and the air, will be prepared as opportunities offer, but in some instances the collections will be studied in conjunction with other material and will not form the subject of a special report.

Acknowledgements and thanks are due to many individuals and institutions whose material aid or advice contributed greatly to the expedition. Foremost among them is Major H. W. Hall, O.B.E., M.C., who not only provided the ship and was responsible for most of the preliminary organization, but who, with Mrs. Hall, accompanied the expedition taking a large share of the actual collecting and doing most of the photography. A small selection of the photographs is published here to give a general impression of the gulf and its surroundings. Many localities could not have been visited but for the skilful pilotage of Captain Hargreaves through poorly charted

waters, and to him, and to his hard-working crew, all possible thanks are due. The Hydrographer of the Navy and the Director of 'Discovery Investigations' lent apparatus vital to the expedition and His Excellency the Egyptian Ambassador in London made arrangements that ensured pleasant and harmonious relations wherever the ship was in Egyptian waters. Lastly, thanks are due to the Government Chemist, whose department carried out the analyses of salinities.

Except for the plankton and some of the fishes all material was obtained from littoral areas and coral reefs (or coral patches). Localities where collections were made are indicated on the chart. Within the Gulf of Aqaba (reading from north to south) these were:

Aqaba (Pl. 22, fig. 1)
Faraun Island (Pl. 22, fig. 2)
Graa
Mualla (Pl. 23, fig. 3)
Hobeik (Pl. 23, fig. 4)
Dahab (Pl. 24, fig. 5)
Um Nageila (Pl. 24, fig. 6)
Abu Zabad

Along the Sinai shores there are well-formed coral reefs at Dahab and from Um Nageila southwards. The bulk of the invertebrate material was obtained from these regions, particularly from Abu Zabad on the 10th and 11th February 1949 when there were low spring tides. North of Dahab there were coral patches at all localities visited, but these never become massed to form a definite reef.

Outside the gulf collections were made at the following localities:

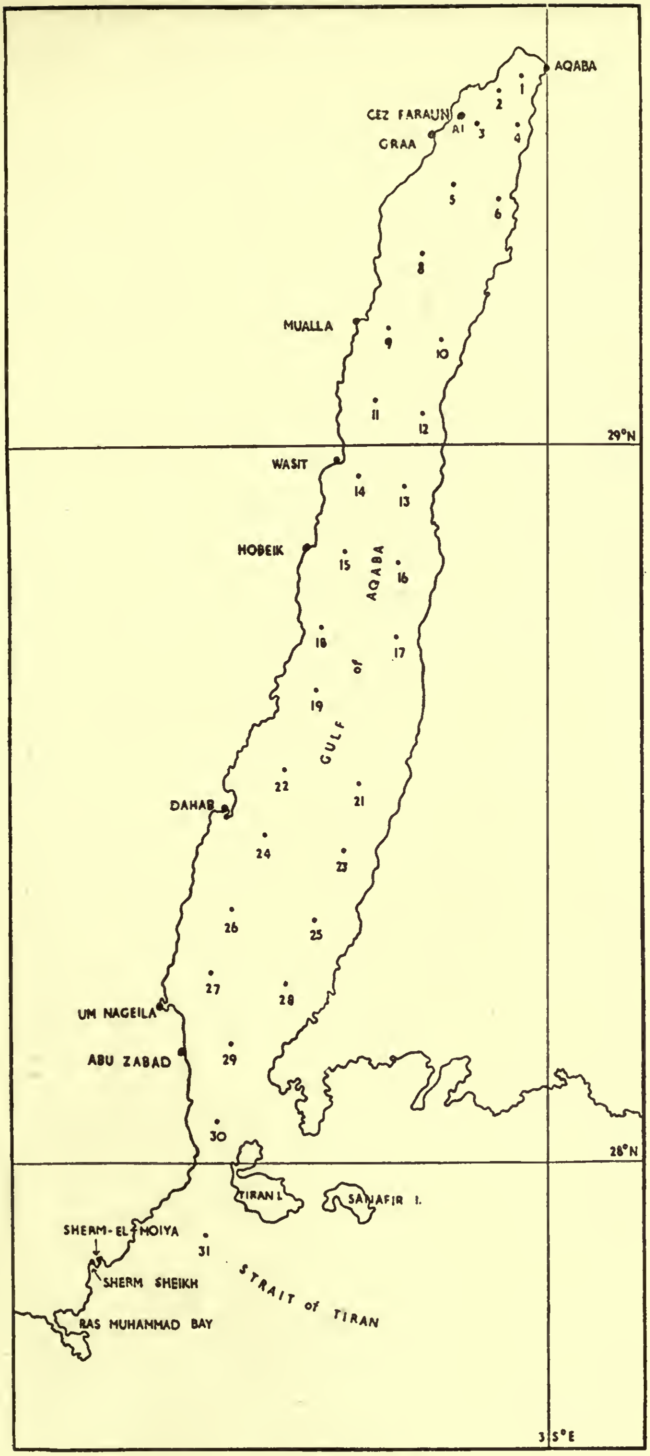
Sanafir Island (Pl. 25, fig. 7)
Tiran Island (Pl. 25, fig. 8)
Sherm Sheikh
Sherm-el-Moiya (Pl. 26, fig. 9)
Ras Muhammad Bay (Pl. 26, fig. 10)

Most time was spent on Sanafir Island, where there were well-formed coral reefs. Here, as elsewhere, much material was collected by diving for pieces of coral and extracting the small invertebrates and fishes.

It will be observed that in the Station List no temperatures are given for depths below 40 metres. It was, however, established that at all stations where deep-water samples were taken (i.e. where salinity figures are given in the list) the temperature exceeded 18·5° C.

The following are the meanings of the abbreviations used in the list.

D.M. = Dredge, medium.
D.S. = Dredge, small.
K.T. = Kelvin tube.
N. 70 V. = Vertical haul by silk plankton net with mouth 70 cm. diameter.
N. 100 V. = Vertical haul with stramin plankton net with mouth 100 cm. diameter.
O.T.L. = Otter trawl, large.



The Gulf of Aqaba.
The positions of the numbered stations are given in the station list.

Station	Position	Date	Hour L.M.T.	Sounding (metres)	Wind: Direction	Wind: Force	Barometer (inches)	Hydrological obs.: Depth (metres)	Hydrological obs.: Temp. °C.	Hydrological obs.: S‰	Bathythermograph obs.: Depth (metres)	Bathythermograph obs.: Temp. °C.	Biological observations: Gear	Biological observations: Depth (metres)	Time: From	Time: To	Remarks
A 1	29° 26′ 30″ N.	1948	1140–	40	N.	3	29·8	0	22·1	40·8	—	—	D.M.	40	1155	1200	No catch: net torn off.
	34° 51′ 30″ E.	31.xii	1237										D.S.	40	1227	1231	No catch.
													N. 100 V.	36	1215	1225	K.T.
1	29° 30′ 54″ N.	1949	1300–	356	S.	1	29·55	0	21·59	40·79	0	21·4	N. 100 V.	c. 180	1340	1355	
	34° 57′ 30″ E.	15.i	1415					137	—	40·78	40	20·8					
								274	—	40·38							
2	29° 29′ 54″ N.	15.i	1435–	165	S.	1	29·55	0	21·65	40·78	0	21·3	N. 100 V.	73	1440	1455	K.T.
	34° 55′ 30″ E.		1500					137	—	40·71	40	20·8					
3	29° 27′ 00″ N.	15.i	1515–	289	S.	1	29·5	0	21·61	40·77	0	21·3	N. 100 V.	79	1550	1600	K.T.
	34° 53′ 36″ E.		1555					137	—	40·67	40	20·9					
								219	—	40·8							
4	29° 26′ 6″ N.	15.i	1625–	713	S.	1	29·55	0	21·62	40·78	0	21·3	N. 100 V.	—	—	—	Net lost.
	34° 57′ 18″ E.		1655					274	—	—	40	21·0					
								549	—	40·72							
5	29° 21′ 36″ N.	16.i	1150–	642	SW.	2	29·35	0	21·61	40·72	0	21·1	N. 70 V.	c. 140	1255	1310	
	34° 51′ 12″ E.		1410					137	—	40·68	40	20·8					
								274	—	40·8							
6	29° 20′ 18″ N.	16.i	1010–	697	SW.	2	29·35	0	21·56	40·74	0	21·1	N. 70 V.	c. 140	1105	1115	
	34° 55′ 24″ E.		1115					137	—	40·8	42	20·8					
								274	—	40·79							
8	29° 15′ 42″ N.	16.i	1350–	274	SW.	1	29·35	0	21·72	40·79	0	21·1	N. 70 V.	c. 140	1422	1435	
	34° 47′ 42″ E.		1440								42	20·8					
9	29° 09′ 24″ N.	16.i	1455–	830	SW.	1	29·35	0	21·57	40·75	0	21·2	N. 70 V.	c. 140	1515	1527	
	34° 45′ 24″ E.		1540					274	—	40·79	42	20·8					
								548	—	40·66							
10	29° 08′ 30″ N.	17.i	0845–	914	SW.	1	29·3	0	21·38	40·8	0	21·1	N. 70 V.	c. 180	0940	1000	
	34° 50′ 00″ E.		1000					274	—	40·72	42	20·7					
								731	—	40·68							
11	29° 03′ 36″ N.	17.i	1105–	293	SW.	1	29·3	0	21·51	40·76	0	21·1	N. 70 V.	c. 140	1113	1125	
	34° 43′ 00″ E.		1125								40	20·8					
12	29° 02′ 00″ N.	17.i	1015–	805	SW.	1	29·3	0	21·53	40·77	0	21·1	N. 70 V.	c. 180	1025	1045	
	34° 48′ 30″ E.		1045								42	20·8					
13	28° 56′ 12″ N.	17.i	1240–	1019	SW.	2	29·4	0	22·0	40·74	0	21·3	N. 70 V.	c. 140	1309	1325	
	34° 46′ 42″ E.		1330								40	20·7					

14	28° 57′ 00″ N. 34° 42′ 30″ E.	17.i	1145– 1215	503	SW.	1	29·3	0 137 274	21·63 — —	40·73 40·75 40·74	0 42	21·0 20·7	N. 70 V.	*c.* 180	1158	1215	
15	28° 50′ 48″ N. 34° 41′ 24″ E.	18.i	0930– 1000	598	S.	1	29·55	0	21·35	40·71	0 42	21·2 20·7	N. 70 V.	*c.* 180	0940	1000	
16	28° 49′ 54″ N. 34° 46′ 06″ E.	18.i	1025– 1110	>1500	S.	1	29·55	0	21·74	40·70	0 42	21·1 20·8	N. 70 V.	*c.* 180	1035	1110	
17	28° 43′ 36″ N. 34° 45′ 26″ E.	18.i	1150– 1220	—	S.	1	29·55	0 137 274	21·88 — —	40·63 40·71 40·73	0 42	21·4 21·0	N. 70 V.	*c.* 180	1200	1220	
18	28° 44′ 30″ N. 34° 38′ 24″ E.	18.i	1310– 1415	942	S.	1	29·55	0	21·57	40·78	0 42	21·1 20·7	N. 70 V.	*c.* 180	1348	1415	
19	28° 39′ 06″ N. 34° 38′ 00″ E.	18.i	1430– 1530	>1460	S.	1	29·5	0 137 820	21·58 — —	40·78 40·74 40·66	0 40	21·2 20·7	N. 70 V.	*c.* 180	1505	1530	
21	28° 31′ 30″ N. 34° 42′ 18″ E.	19.i	1120– 1200	—	NW.	2	29·65	0 137 550	21·56 — —	40·70 40·74 40·64	0 40	21·1 20·8	N. 70 V.	*c.* 180	1145	1200	
22	28° 32′ 48″ N. 34° 35′ 00″ E.	19.i	1000– 1040	—	NW.	2	29·65	0 137 550	21·22 — —	40·76 40·72 40·67	0 40	21·1 20·8	N. 70 V.	*c.* 180	1009	1040	
23	28° 25′ 36″ N. 34° 40′ 54″ E.	19.i	1230– 1300	—	NW.	2	29·65	0	21·81	40·53	0 40	21·5 20·9	N. 70 V.	*c.* 180	1240	1300	
24	28° 27′ 12″ N. 34° 33′ 20″ E.	19.i	0900– 0930	850	NW.	2	29·65	0	21·20	40·75	0 33	20·9 20·7	N. 70 V.	*c.* 180	0909	0930	
25	28° 20′ 12″ N. 34° 38′ 12″ E.	19.i	1400– 1430	—	N.	2	29·6	0	22·20	40·61	0 26	21·7 21·3	N. 70 V.	*c.* 180	1410	1430	
26	28° 20′ 54″ N. 34° 30′ 18″ E.	20.i	0900– 0920	—	N.	3	29·65	0	21·40	40·70	0 33	21·2 21·0	N. 70 V.	*c.* 180	0903	0920	
27	28° 15′ 42″ N. 34° 28′ 00″ E.	20.i	0950– 1045	—	N.	3	29·65	0 137 550	21·45 — —	40·59 40·66 40·66	0 38	21·4 21·1	N. 70 V.	*c.* 180	1020	1045	
28	28° 14′ 36″ N. 34° 35′ 12″ E.	20.i	1125– 1210	—	NNE.	4	29·6	0 137 460	21·44 — —	40·66 40·66 40·66	0 35	21·3 21·0	N. 70 V. O.T.L.	*c.* 180 *c.* 250	1149 1300	1210 1500	Catch nil.
29	28° 09′ 30″ N. 34° 30′ 6″ E.	21.i	1000– 1030	—	N.	2	29·75	0	21·50	40·66	0 42	21·1 20·9	N. 70 V.	*c.* 180	1008	1030	
30	28° 03′ 00″ N. 34° 28′ 42″ E.	21.i	1100– 1150	—	N.	2	29·75	0 137 550	22·38 — —	40·50 40·66 40·68	0 42	21·9 21·4	N. 70 V.	*c.* 180	1129	1150	
31	27° 53′ 24″ N. 34° 27′ 36″ E.	3.ii	1400– 1445	—	N.	1	29·6	0 137 730	22·54 — —	40·48 40·46 40·48	0 38	21·7 21·1	N. 70 V.	*c.* 180	1425	1445	

Stations 7 and 20 were planned but never worked.

Legends to Plates 22–27.

PLATE 22

FIG. 1. Aqaba looking north-east.
FIG. 2. Gezeret-el-Faraun from the south-east.

PLATE 23

FIG. 3. Looking north from the anchorage at Mualla.
FIG. 4. Hobeik.

PLATE 24

FIG. 5. Typical gulf scenery. Coast 5 miles south of Dahab.
FIG. 6. Mangrove swamps at Um Nageila.

PLATE 25

FIG. 7. Sanafir Island; Fish-eagle's nest.
FIG. 8. Tiran Island, seen from Sanafir.

PLATE 26

FIG. 9. Sherm-el-Moiya; looking north-east from the entrance.
FIG. 10. *Manihine* at anchor in Ghazulani Bay with Ras Muhammad in the distance.

PLATE 27

FIG. 11. Abandoned police post at Naweibi-el-Terabin, about 45 miles south of Aqaba.
FIG. 12. Arab fisherman using cast net.

FIG. 1. AQABA

FIG. 2. GEZERET-EL-FARAUN

FIG. 3. MUALLA

FIG. 4. HOBEIK

Fig. 5. GULF SCENERY NEAR DAHAB

Fig. 6. UM NAGEILA

FIG. 7. SANAFIR ISLAND

FIG. 8. TIRAN ISLAND

Fig. 9. SHERM-EL-MOIYA

Fig. 10. GHAZULANI BAY

FIG. 11. NAWEIBI-EL-TERABIN

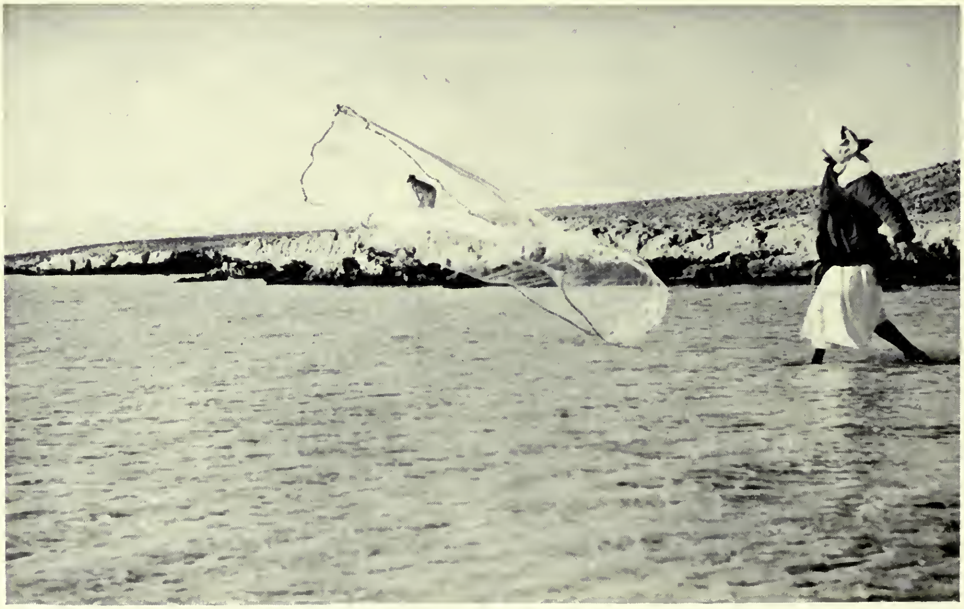


FIG. 12. CAST NET

II. PRELIMINARY HYDROLOGICAL REPORT

By G. E. R. DEACON, F.R.S.

NATIONAL INSTITUTE OF OCEANOGRAPHY

The observations confirm the general picture of the water circulation described by A. F. Mohammed in *Proc. Roy. Soc.* B. **128,** 1939, and give some new information about the surface layer.

As plotted in Fig. 1, the surface water at Stations 30 and 31 in the Straits of Tiran, and at Station 23 twenty miles farther north on the east side of the gulf, had a salinity less than 40·6‰ which can be attributed to the inflow of water from the Red Sea. There is some indication that the inward movement has a greater influence on the east side of the gulf since the surface salinity at Station 17 nearly half-way up the gulf is only 40·63‰. For the remainder of the gulf, including all stations north and west of a line from Station 26 to Station 17, the water between the surface and 20 fathoms can be regarded as almost isothermal and isohaline, with a temperature of 21° to 22° C. (in January) and a salinity of 40·7 to 40·8‰.

Excepting Stations 31, 30, and 25, the observed surface temperature appears to depend more on the time of day at which the measurement was made than the position of the station in the gulf. When plotted against time of day (Fig. 2) the temperatures lie fairly closely about a curve of diurnal temperature change which has a maximum at approximately 13.00 hours. The bathythermograph observations made at all the stations always show a temperature less than that measured by taking a surface sample and using a thermometer. Some of the differences can be attributed to the shallower depth of the sample scooped up in a surface sampler, and to the existence of an appreciable thermal gradient in the first foot or two of water. The differences between the thermometer and bathythermograph readings when plotted against the time of day (Fig. 3) lie fairly closely about a curve with a maximum of 0·55° C., which is very similar to that showing the diurnal temperature variation (Fig. 2) at 13.00 hours. The differences between the readings at the surface and a depth of 40 metres on the bathythermograph slides (Fig. 4) shows that this difference, which varies between 0·2° and 0·6° C., varies according to a similar curve.

It is expected that some further information about the interchange of heat and water vapour between the surface water and the air can be obtained from the data, and, when some attempt is made to smooth out the diurnal temperature variations, one or two useful indications of the surface movements; but the best that can be done at present is to regard the upper 40 metres of water as more or less uniform, excepting Stations 31, 30, and 23. These appear to be influenced by the inflow of surface water from the Red Sea. Reference to Fig. 1 will also show that the stations near the eastern shore in the southern part of the gulf appear to be influenced by a more recent inflow of water than those farther north and west.

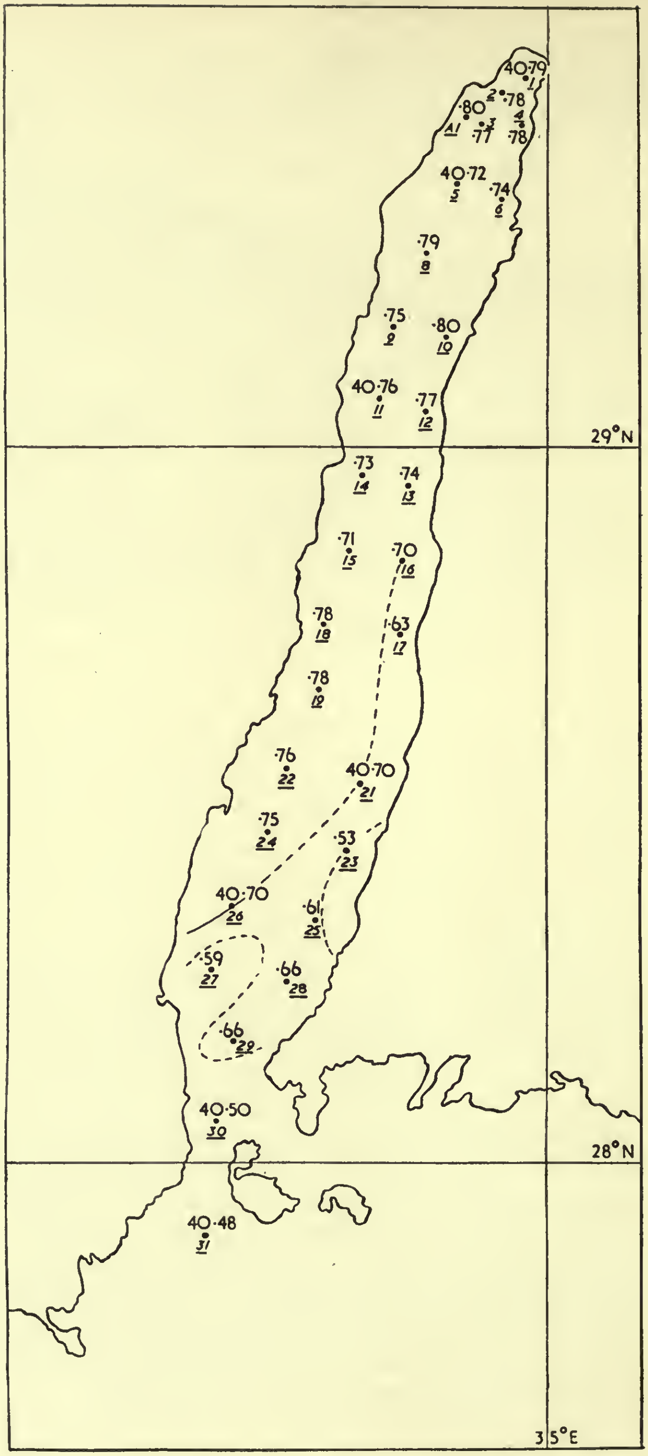


Fig. 1. Surface salinities. The underlined figures are the station numbers.

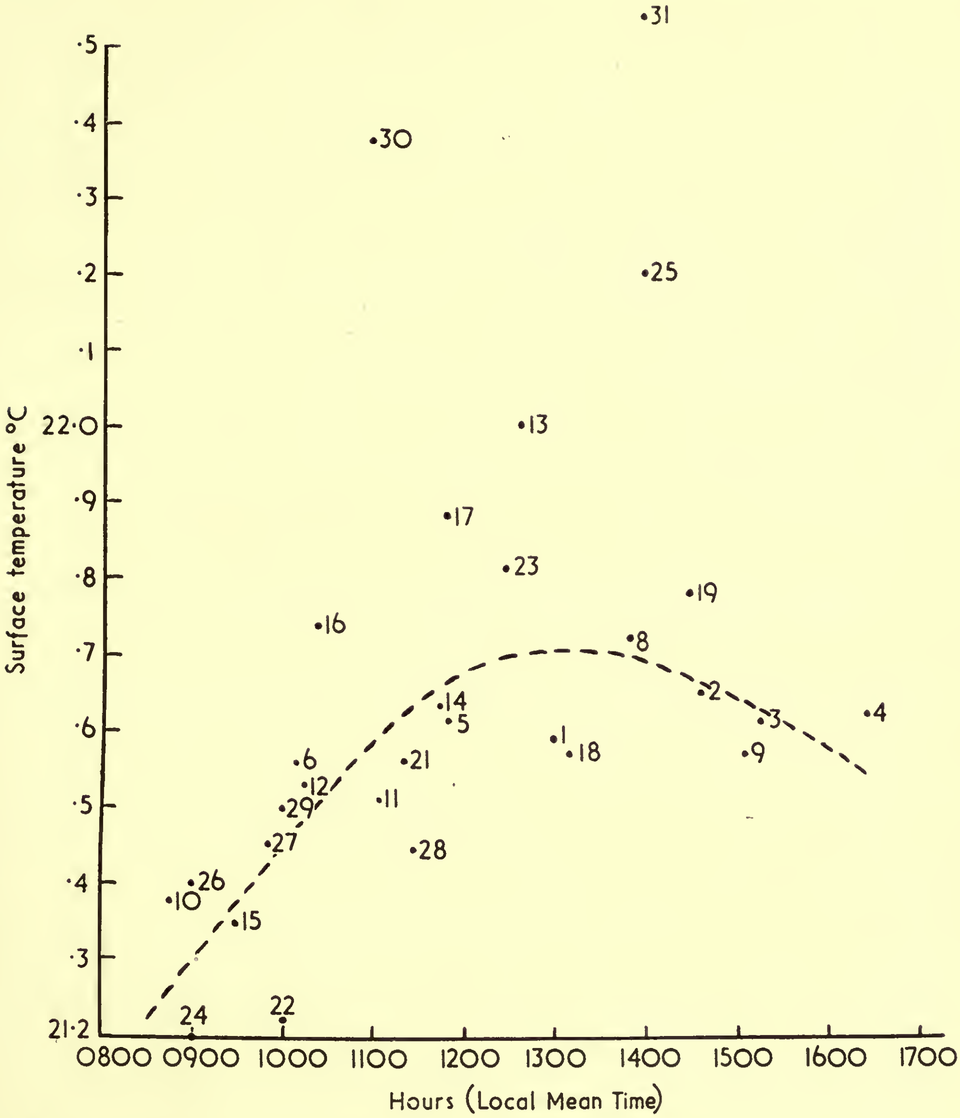


FIG. 2. Surface temperature in relation to time of day. (Numbers refer to stations.)

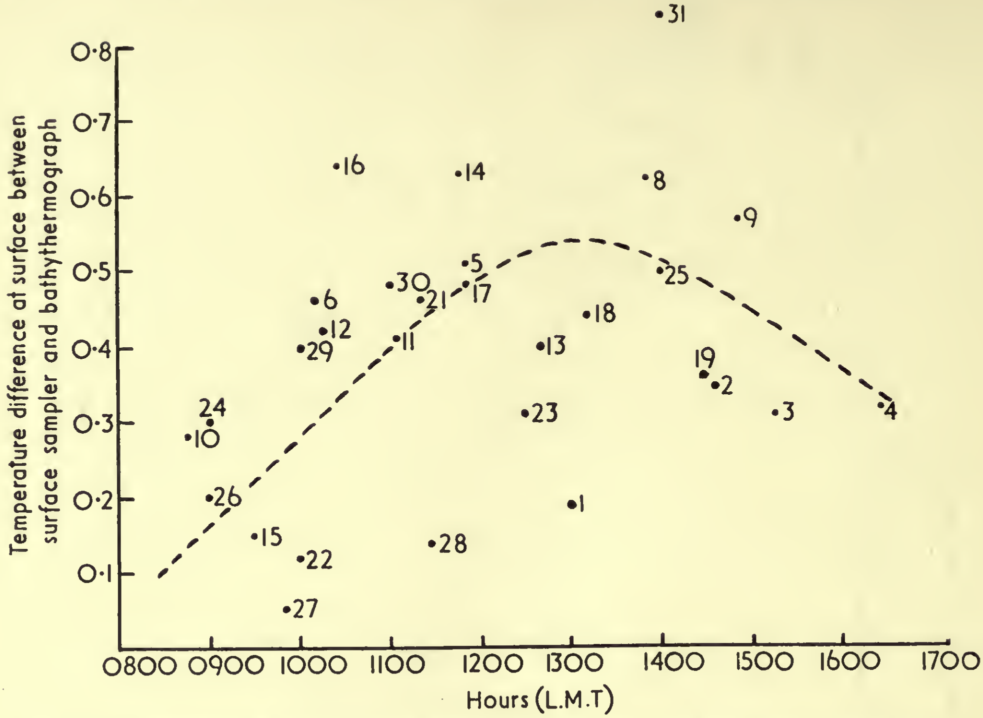


FIG. 3. Difference of temperature between surface samples and bathythermograph 'surface' recordings, plotted against time of day. (Numbers refer to stations.)

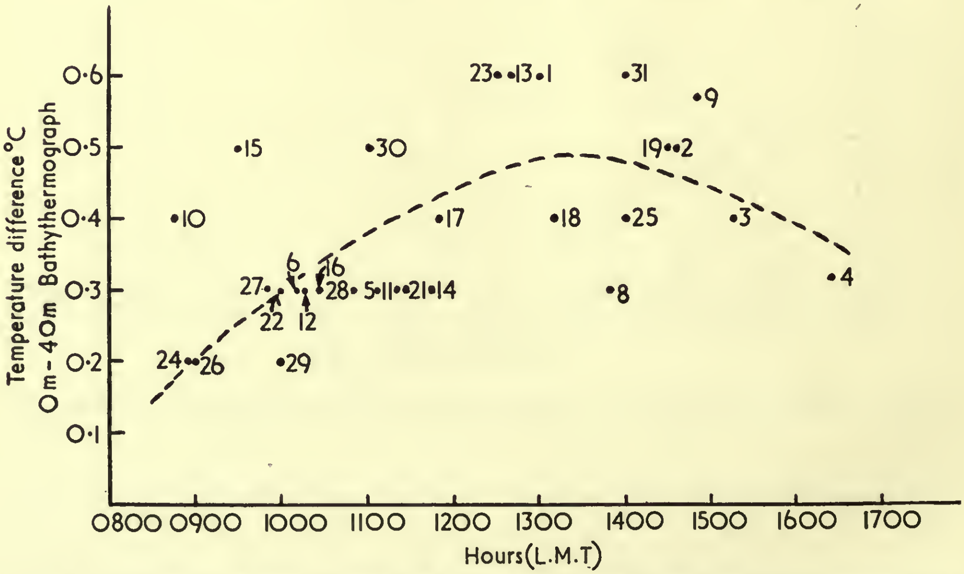


FIG. 4. Difference between temperature at surface and at 40 metres, plotted against time of day. (Numbers refer to stations.)

III. SPONGES

By MAURICE BURTON, D.SC.

The sponges represent thirty-three species, and although their study has resulted in little of unusual interest, a useful addition to the faunal list of the Red Sea area has been made. In addition, it has been possible to establish the correct identity of some of the forms described by Keller (1889 and 1891), which has long been in doubt. Most of the thirty-three species are common to the Indian Ocean fauna, some having been recorded also from Australia or the Indo-Pacific. It is of interest to note, however, that twelve species appear to be endemic, but this may be due largely to gaps in our knowledge of the Indian Ocean fauna. Furthermore, there are three species (*Leuconia nausicae*, *Tethya aurantium*, and *Pseudosuberites mollis*) belonging more properly to the Mediterranean fauna.

The commonest form in the Gulf of Aqaba seems to be *Callyspongia viridis*, which, according to the members of the expedition, is 'abundant everywhere'.

LIST OF SPECIES AND SYSTEMATIC NOTES

Order CALCAREA

Leucosolenia canariensis (Michlucho-Maclay)

Nardoa canariensis Michlucho-Maclay, 1868: 221.
Leucosolenia canariensis, Dendy & Row, 1913: 724.

Occurrence. Mualla, 30.i.49, under rocks at low tide; Sherm-el-Moiya, 3.ii.49.

Remarks. A greyish white, typical specimen, 10 mm. across.

Distribution. Arctic; Mediterranean; Cape Verde Islands; Canaries; Red Sea; Mauritius; NW. Pacific (Commandorski Islands).

Leucosolenia tenuipilosa Dendy

Leucosolenia (*Clathrina*) *tenuipilosa* Dendy, 1905: 227, pl. xiii, fig. 9.
L. canariensis (pars), Thacker, 1908: 762.
Clathrina tenuipilosa, Row, 1909: 185.
Leucosolenia tenuipilosa, Dendy & Row, 1913: 723.

Occurrence. Dahab, 14.ii.49; Abu Zabad, 11.ii.49.

Remarks. There are a number of typically cushion-shaped specimens, up to 30 mm. across, which were brown or fawn in formalin, and now, in spirit, are coloured a greyish brown.

Distribution. Ceylon; Red Sea; Cape Verde Islands.

Grantessa glabra Row

Grantessa glabra Row, 1909: 203, pl. xix, figs. 5–6; Dendy & Row, 1913: 752.

Occurrence. Sherm Sheik, 11.i.49; Abu Zabad, 10.ii.49, on reef at low tide.

Distribution. Red Sea.

Leuconia bathybia (Haeckel)

Dyssycum bathybia Haeckel, 1869: 241.
Leucaltis bathybia, idem, 1872: 156, pl. xxviii, fig. 2.
Leucandra bathybia, Dendy & Row, 1913: 773.

Occurrence. Sherm Sheik, 2.ii.49, 2 fms.; Sanafir, 6.ii.49.

Remarks. The four specimens may possibly represent two well-marked varieties, and, since the species was originally subdivided in this manner, it may be worth while to consider them in this light.

The first specimen is the smaller, a few millimetres high, and of typical form and colour. The skeleton is arranged as Haeckel described it, and the rays of the large quadriradiates have a maximum of 0·4 by 0·032 mm.

The other three range from a few millimetres high to 16 mm. high by 12 mm. diameter. Again, the external form is typical, as well as the spiculation. But in these three the rays of the quadriradiates have a maximum of 0·96 mm. by 0·09 mm.

Either the first of the present specimens represents Haeckel's var. *perimina* and the other three var. *arabica*, or, what is much more likely, we have to deal with a species showing a tendency to vary widely in the measurements of the spicules.

The first specimen and two out of the group of three were found at the same station, Sherm Sheik.

Distribution. Red Sea; ? Australia.

Leuconia nausicae (Schuffner)

Leucaltis nausicae Schuffner, 1877: 407, pl. xxiv, fig. 1.
Leucandra nausicae Dendy & Row, 1913: 774.

Occurrence. Sanafir, 9.i.49; Tiran, 10.i.49; Abu Zabad, 11.ii.49, on reef at low tide.

Remarks. The two specimens seem to agree closely with the description of the holotype, which is the only other recorded specimen. Presumably Row (l.c.) examined this and, as a consequence, the species was transferred to *Leucandra*. It is difficult, therefore, to accept Topsent's (1937: 14) remark that '*Leucaltis Nausicae* Schuffner se confond vraisemblablement avec *Leucetta solida* (O. Schmidt)'.

Distribution. Mediterranean.

Kebira uteoides Row

Kebira uteoides Row, 1909: 210, pl. xx, figs. 8–9, text-figs. 7–8; Dendy & Row, 1913: 785.

Occurrence. Sherm Sheik, 2 fms., 2.ii.49.

Remarks. The single specimen, 20 mm. high, is typical, in both external appearance and the details of the skeleton.

Distribution. Red Sea.

Order TETRAXONIDA

Stelletta purpurea Ridley

(For synonymy *see* Burton, 1926.)

Occurrence. Tiran, 10.i.49; Sanafir, 8 and 9.i.49 and 4.ii.49; Sherm-el-Moiya, 3.ii.49.

Remarks. The spiculation of the several specimens shows the usual variation in

size. The main interest lies, however, in the external form. The smallest specimens, 10 to 15 mm. diameter, have the spherical or subspherical shape typical of the species, but in one or two cases these small spherical sponges have coalesced to give an irregular lobulated mass. In the larger specimens, 50 to 60 mm. across, on the other hand, the form is often extremely irregular, suggesting not only the coalescence of several smaller sponges but irregularities of growth due to environmental factors.

Distribution. Red Sea; Indian Ocean; Malay; Australasia; Antarctic.

Chondrilla sacciformis Carter

(For synonymy *see* Burton, 1924.)

Occurrence. Sherm-el-Moiya, 3.ii.49.

Distribution. Indian Ocean; Malay.

Chondrosia reniformis Nardo

Chondrosia reniformis Nardo, 1847: 272.

Occurrence. Abu Zabad, 11.ii.49.

Remarks. The two specimens appear to be typical except that there is a sparse accumulation of fine sand grains in the outer layers of the cortex.

Distribution. Atlantic coast of Europe; Mediterranean; South Africa (Stil Bay); Indian Ocean; Malay; Australia.

Chrotella cavernosa (Lamarck)

Tethya cavernosa Lamarck, 1813: 70; 1815: 385.
T. cranium var. *australiensis* Carter, 1886: 127.
Cinachyra australiensis, Burton, 1934: 523.
(For further synonymy *see* Burton, l.c.)

Occurrence. Mualla, 30.i.49, at low tide under rocks.

Distribution. Red Sea; Indian Ocean; Malay; Australia; Philippines.

Tethya aurantium (Pallas)

(*See* Burton 1924 and 1949: 122.)

Occurrence. Sherm Sheik, 2.ii.49, 11.i.49, and 2.ii.49; Tiran, 10.i.49; Mualla, 30.i.49, at low tide under rocks.

Remarks. The five specimens, all somewhat flattened, are fawn, orange, or red (in formalin) and measure 7, 8, 12, 18, and 21 mm. across respectively.

Distribution. Arctic; North Atlantic; West Indies; Mediterranean.

Tethya robusta Bowerbank

(For synonymy *see* Burton, 1924.)

Occurrence. Mualla, 30.i.49, under rocks at low tide; Abu Zabad, 10 and 11.ii.49, on reef at low tide.

Remarks. The six specimens measure 13, 15, 21, 25, 26, and 28 mm. across respectively. The colour (in formalin) is pink to red. There is, however, another specimen

consisting of five lobes set in a horizontal plane, each lobe being about 20 mm. across. Its colour was a cerise-red in formalin. Clearly this specimen has been formed by the complete coalescence of five adjacent individuals. It is not unknown for two specimens to fuse in this way, but five is unusual.

The spiculation is typical in all but two specimens, which lack the larger micrasters. In other words, these two should be assigned to *Tethya japonica* Sollas. In 1924 I suggested that this so-called species was probably a reduced form of *T. diploderma* Schmidt (= *T. ingalli* Bowerbank), but it now seems that it is a mixture of the reduced forms of both *T. robusta* and *T. ingalli*.

Distribution. Australia; Malay; Indian Ocean.

Pseudosuberites mollis Topsent

Pseudosuberites mollis Topsent, 1925: 9, fig. 2*m*.

Occurrence. Mualla, 30.i.49, under rocks at low tide.

Remarks. The sample consists of three fragments of a soft and delicate sponge, having approximately the characters described by Topsent (l.c.). The spicules are slightly larger, 0·15 to 0·45 by 0·005 to 0·008 mm., as compared with 0·175 to 0·315 by 0·0065 mm. in the holotype, but the variations in the shape of the spicules are similar to those figured by Topsent.

Distribution. Mediterranean (Étang de Thau).

Haliclona toxophorus (Hentschel)

Gellius toxophorus Hentschel, 1912: 392, pl. xxi, fig. 46.
G. toxotes, idem, l.c.: 392, pl. xxi, fig. 47.

Occurrence. Sherm Sheik, 11.i.49.

Remarks. The two small fragments are evidently from one sponge which formed a flattened, massive incrustation, with oscules slightly raised. Almost transparent, soft and compressible, delicate in texture, the specimen appears to be denuded of flesh, the skeleton, an isodictyal and unispicular network, being held together by spongin at the nodes. The megascleres are oxea, with a tendency to become strongylote at one or both ends, 0·24 by 0·012 mm. The microscleres are toxa, 0·02 to 0·1 mm. across.

The two species described by Hentschel were sufficiently closely related, judging by the original descriptions, to suggest their identity one with the other. The intermediate character of the present material adds point to this.

Distribution. Malay.

Adocia dendyi (Burton)

Toxochalina robusta Dendy, 1905: 139; idem, 1921: 29.
T. dendyi Burton, 1931: 340, fig. 2*b*.
Nec *Toxochalina robusta* Ridley.

Occurrence. Sherm Sheik, 11.i.49.

Remarks. The several specimens are all small and cushion-shaped, with conspicuous oscules 2 to 3 mm. diameter. The colour, in spirit, is brownish grey, and

the texture soft, compressible, elastic. The main skeleton is a close-meshed reticulation of fibres, the ascending fibres multispicular (3 to 4 spicules), the connectives unispicular. The tangential dermal skeleton is very much as figured by me (l.c., fig. *2b*) and is unispicular. The spicules are oxea 0·1 by 0·004 mm., and toxa of about the same length.

Distribution. Indian Ocean.

Callyspongia viridis (Keller)

Dactylochalina viridis Keller, 1889: 391, pl. xxiii, figs. 37–43.

Occurrence. Sherm Sheik, 2 and 3.ii.49; Tiran, 10.i.49; Abu Zabad, 10 and 11.ii.49, on reef at low tide; Dahab, 13.i.49 and 14.ii.49; Sanafir, 4, 5, and 6.ii.49.

Remarks. Of the eleven specimens, only one is almost identical with that figured by Keller (l.c., fig. 37), nine of the remainder being irregularly massive, on the whole smaller, and the eleventh being no more than a thin incrustation on a coral. All have the typical vents and the typical pore-sieves (Keller, l.c., fig. 40), although in some cases the pore-sieves are less strongly marked. In a few cases, at least, the characters of the surface have been blurred by preservation in formalin.

The characters of the skeleton are comparatively uniform for the nine irregularly, massive specimens, but the typical specimen and the thin incrustation show features which merit special notice. In the nine specimens the network of the main skeleton consists of well-marked primary or ascending fibres which branch, as they run to the surface, in a somewhat irregular manner. At the centres of the fibres is a more or less continuous core of spicules arranged in an untidy manner (almost irregularly sub-plumose), often with individual spicules projecting from the fibres. The primary fibres are connected by secondary fibres, thinner than the primaries, and forming often an irregular network. In these the spicules are arranged, usually, uniserially; but, again, individual spicules may project, at right angles to the main series, beyond the surface of the fibres. The tangential skeleton at the surface is a close-meshed network of fibres, cored by uniserially arranged oxea, and showing no obvious differentiation into primary and secondary meshes. The average diameter of the meshes is 0·04 mm. The oxea vary from 0·08 to 0·16 by 0·004 to 0·005 mm.

The main skeleton of the one typical specimen (i.e. externally typical) is unlike that of the nine specimens in that it approaches the ceraochalinoid condition. It is a very close-meshed reticulation of thick fibres which appear at first sight to be aspiculous. In general it resembles that shown in Keller's fig. 39. On closer examination, however, it can be seen that the spicules are present, are reduced in numbers, and seldom more than 0·002 mm. thick; and often a spicule may be discontinuous throughout its length (as though breaking up).

As a result of comparing the external forms of these sponges, as well as the structure of their skeletons, there seems little doubt that they are all conspecific and that the variation in their skeletons is unimportant. Generally speaking, it seems that in the younger sponges and the newer tissues the reticulation of the fibres is more loose and the fibres themselves more heavily cored with spicules; that with maturity the skeleton is more closely knit and the proportion of spicule to spongin decreases (cf.

Burton, 1926: 265). One further point may be mentioned. In the specimen, described above as typical, the spicules have the appearance, as a result of their slender build and the discontinuous structure already referred to, of being dissolved or absorbed. Whether, in fact, this is the case is, however, problematical.

The colour of the present specimens, in formalin, was grey to fawn.

Distribution. Red Sea.

Gelliodes fibulatus Ridley

Gelliodes fibulatus Ridley, 1884: 427, pl. xxxix, fig. 1, pl. xli, fig. *b*; Ridley & Dendy, 1887: 47, pl. xii, fig. 2; Lendenfeld, 1887: 793.
Pachychalina fragilis, Lindgren, 1897: 481; idem, 1898: 290.
Gelloides ramosa Kieschnick, 1898: 47.
? *Pachychalina conulosa*, idem, l.c.: 51.
Gelliodes ramosa, idem, 1900: 565, pl. xliv, fig. 3.
? *Pachychalina conulosa*, idem, l.c.: 568, pl. xliv, fig. 8.
Gelliodes fibulatus, Hentschel, 1912: 393.
Sigmaxynissa fibulata, Burton, 1928: 115.

Occurrence. Graa, 30.i.49; Sherm-el-Moiya, 3.ii.49; Sanafir, 6.ii.49.

Remarks. It is somewhat surprising to find what appear to be typical examples of this species so far west as the Gulf of Aqaba. All records previously have been for the Malay region and the Indian Ocean (Andaman Islands).

Distribution. Malay; Indian Ocean; (? Australia).

Mycale euplectellioides Row

Esperella euplectellioides Row, 1911: 333, pl. xxxvii, fig. 12, text-fig. 16.
Mycale euplectellioides, Burton, 1926: 80.

Occurrence. Sherm Sheik, 2.ii.49; Graa, 30.i.49; Dahab, 13.i.49; Sanafir, 4 and 6.ii.49.

Remarks. The sponge occurs in irregular masses on coral, the largest being some 30 mm. across. Externally there is a close resemblance to the type, and from the condition of the several specimens, when removed from the formalin in which they were originally preserved, it is clear that a copious amount of mucus is present in life.

The skeleton is typical except that microscleres are extremely rare, none being found except in a section from one specimen, which contained a few sigmata, 0·05 to 0·08 mm. chord, and one anisochela 0·024 mm. chord.

Distribution. Red Sea; Suez Canal.

Mycale (Carmia) suezza (Row)

Esperella suezza Row, 1911: 338, fig. 18.

Occurrence. Mualla, 31.i.49; Dahab, 14.ii.49.

Remarks. Two samples are assigned doubtfully to this species. The first is a thin incrustation, orange-coloured in formalin, and a larger, irregularly massive sponge, having the same colour and general appearance. The skeleton has the same structure as the holotype of *Mycale suezza*, but in neither specimen has it been possible to find a single microsclere.

Distribution. Red Sea.

Mycale (Aegagropila) erythraena (Row)

Esperella erythraena Row, 1911: 340, fig. 19.
Mycale erythraena, Burton, 1926: 80.

Occurrence. Dahab, 4.ii.49.

Remarks. The single specimen forms a thin, irregular incrustation on coral. Its colour, in formalin, was grey. The arrangement of the skeleton approximate closely to the type, and the megascleres are typical in form and size; but in spite of repeated searching not a single microsclere has been found.

Distribution. Red Sea; Suez Canal.

Genus *PARISOCIELLA* gen. n.

Type Species. Esperiopsis anomala, Ridley & Dendy, 1886: 341.

Diagnosis. Mycaleae with skeleton an irregular reticulation of spongin fibres cored by slender tylostyli; microscleres, when present, degenerate anisochelae palmatae and toxa.

Parisociella anomala (Ridley & Dendy)

Esperiopsis anomala Ridley & Dendy, 1886: 341; idem, 1887: 84.
Ceraochalina gibbosa Keller, 1889: 386, pl. xxiv, fig. 44.
Ophlitaspongia arbuscula Row, 1911: 347, pl. xxxix, fig. 22, pl. xl, fig. 25, text-fig. 22.
O. horrida, idem, l.c.: 349, pl. xl, fig. 26, text-fig. 23.

Occurrence. Sanafir, 4 and 9.ii.49, along the shore among rocks; Abu Zabad, 10.ii.49, on reef at low tide.

Diagnosis. Sponge typically branching, surface uneven, minutely hispid; oscules not apparent; texture soft, elastic; colour alive red, in spirit greyish yellow to dark grey; main skeleton an irregularly isodictyal reticulation of fibres cored by megascleres; dermal skeleton of radiating brushes of megascleres; megascleres tylostyli, slender and often appearing as styli, 0·25 to 0·3 by 0·002 to 0·005 mm.; microscleres usually absent and never plentiful, anisochelae palmatae, 0·01 mm. chord, and toxa, 0·02 to 0·06 mm. long.

Remarks. The diagnostic features of this species are unsatisfactory, since the microscleres, even when present, exist in such small quantities and are difficult to find. Further, the main skeleton is so like that of *Mycale euplectellioides*, growing in the same habitat, that only the external form remains as a guide to identification. If, therefore, the particular specimen is macerated or fragmentary the possibility of wrong identification is great.

The present three specimens include a fragment of a branch, which is macerated, and two extensive, but low, incrustations on pieces of coral. The colour, in formalin, was orange and yellowish brown, in spirit, yellow or brown. No microscleres were found.

Distribution. Red Sea; Honolulu.

Lissodendoryx cratera (Row)

Myxilla cratera Row, 1911: 343, pl. xxxvii, fig. 13, text-fig. 20.

Occurrence. Abu Zabad, 11.ii.49.

Distribution. Red Sea.

Agelas mauritianus (Carter)

Ectyon mauritianus Carter, 1883: 310, pl. xii, fig. 3.
Agelas mauritianus, Ridley & Dendy, 1887: 164, pl. xxix, fig. 10.
A. cavernosa Thiele, 1903: 963, fig. 28.
A. mauritiana, Dendy, 1905: 174.

Occurrence. Sanafir, 6.ii.49.

Remarks. A fairly large fragment which, in formalin, was pink outside and orange in the interior.

Distribution. Indian Ocean; Malay.

Halichondria glabrata Keller

Halichondria glabrata Keller, 1891: 311, pl. xvi, fig. 9; Burton, 1926: 75.

Occurrence. Abu Zabad, 11.ii.49.

Remarks. A single, thinly encrusting specimen, in colour pale brown, both in formalin and in spirit.

Distribution. Red Sea.

Rhaphoxya typica Hallmann

Rhaphoxya typica Hallmann, 1917: 643, pl. xxix, fig. 3, pl. xxxviii, figs. 8–9, pl. xxxix, fig. 5, pl. xlii, figs. 1–2, text-fig. 17.

Occurrence. Sanafir, 6.ii.49; Abu Zabad, 10.ii.49, on reef at low tide.

Remarks. The several species which may be assigned to *Rhaphoxya* are mainly Australian and none has been previously recorded from the Red Sea, although *Anacanthaea nivea* Row might conceivably belong to this genus. Yet the present two specimens clearly belong to *Rhaphoxya* and are almost certainly conspecific with the genotype. They are both encrusting, but their general appearance and the characters of the surface agree closely with those described and figured by Hallmann, except that the pore-areas (?), in his pl. xxxviii, fig. 8, are not so numerous in the 'Manihine' sponges. There is, also, a close agreement in the shape of the spicules and their arrangement in the skeleton, except that the trichites are not numerous and, as far as can be seen, do not form dragmata.

A striking feature of the anatomy concerns the presence of numerous oval groups of cells, looking very like embryos, which they may well be, except that they vary somewhat in size, from 0·08 to 0·2 mm., with 0·12 mm. as the average, across the long axis. The tissues of the sponge contain numerous brown pigment cells in the surface layers, and the 'embryos' lying in the surface tissues are also filled with them.

Disitribution. Australia.

Order KERATOSA

Aplysilla lacunosa Keller

Aplysilla lacunosa Keller, 1889: 356, pl. xxii, figs. 19–22.

Occurrence. Sanafir, 6.ii.49.

Remarks. A single, very small, incrusting specimen, purple in colour, showing the typical fibres (see Keller, l.c., pl. xxii, fig. 22).

Distribution. Red Sea.

Megalopastas erectus Row

Megalopastas erectus Row, 1911: 360.

Occurrence. Sherm Sheik, 11.i.49; Dahab, 14.ii.49.

Remarks. The two specimens form irregular encrustations, with the surfaces irregularly conulose. The colour of one, in formalin, was purple, in spirit it turned to a deep violet; in the other it was fawn in formalin and the same in spirit.

Distribution: Red Sea.

Spongia officinalis Linnaeus, var. ***arabica*** (Keller)

Euspongia officinalis, var. *arabica* Keller, 1889: 342; Topsent, 1906: 558; Row, 1911: 379.

Occurrence. Abu Zabad, 10 and 11.ii.49, on reef at low tide; Sherm-el-Moiya, 3.ii.49; Sanafir, 9.i.49.

Remarks. There are two typical specimens, two very small specimens in which the skeleton only remains and which are doubtfully assigned to this species, a fifth, typical but very small, and a sixth specimen which agrees in general appearance, but has the internal tissues so crowded with sand that a better identification is not possible.

The colour in formalin varies from fawn (the specimens without flesh) to dark brown.

Distribution. Red Sea.

Heteronema erecta Keller

Heteronema erecta Keller, 1889: 340, pl. xx, figs. 4, 7, 8; Topsent, 1906: 558; Row, 1911: 369.
Duriella nigra Row, 1911: 370, pl. xli, fig. 29.

Occurrence. Dahab, 3.i.49 and 2.ii.49 and 14.ii.49, shore; Sanafir, 5.ii.49.

Remarks. The type of *Duriella nigra* and Row's specimen of *Heteronema erecta* are almost identical in external form though they differ in the structure of the skeleton. Both specimens are, however, massive and lack the digitiform processes of the type of *H. erecta*. There is also available in the British Museum collection a preparation from Keller's type, and comparing this with Row's specimens suggested, in the first place, that the only difference between *Duriella nigra* and *Heteronema erecta* lay in the much greater amount of sand in the fibres of the latter. The 'Manihine' specimens, four in all, have a sufficiently general resemblance to each other, and to the specimens described by Keller and Row, to be considered alongside them. In these, two have a skeleton approximately similar to that of *Duriella nigra*, one is much more like *Heteronema erecta*, and the fourth is intermediate between the two.

With seven specimens thus available for comparison it seems certain that the variation in the skeleton of this species (for *Duriella nigra* and *Heteronema erecta* are here accepted as conspecific) is similar to that shown by me (1934, figs. 18–33) for *Dysidia fragilis*. In other words, that according to the amount of sand present the skeleton will vary from clearly defined ascending fibres cored with sand, connected by a secondary network free of it, to a dense network in which the spongin of all fibres is almost entirely obscured by a heavy intake of sand, with no perceptible differentiation into primary (or ascending) and secondary fibres.

Supporting such a view is the fact that the amount by which the fibres are impregnated with sand varies from one part to another of the skeleton of any individual sponge.

The colour of the 'Manihine' specimens ranged, in formalin, from brown to a deep purple-brown.

Distribution. Red Sea.

Carterispongia clathrata (Carter)

(For synonymy and discussion *see* Burton, 1934: 574.)

Occurrence. Sherm Sheik, 11.i.49; Mualla, 31.i.49; Dahab, 13 and 14.ii.49; Sanafir, 9.i.49 and 4.ii.49; Sherm-el-Moiya, 3.ii.49.

Remarks. The several fragmentary specimens have the typical cavernous appearance. The skeleton differs considerably, however, from one individual to another, and these differences seem to offer a gradation from the typical skeleton of this species to that of *Euryspongia lactea.* It is possible, therefore, that *Euryspongia* may ultimately prove to be synonymous with *Carterispongia.*

The colour of the different specimens, in formalin, ranged from fawn or brown, to purple, with occasional pink patches.

Distribution. Indian Ocean; Australia; (? West Indies).

Hircinia ramosa Keller

Hircinia ramosa Keller, 1889: 345, pl. xx, fig. 5.
H. schulzei Dendy, 1905: 221, pl. xvi, fig. 3.
H. ramosa, Row, 1911: 372; Burton, 1934: 579, pl. 1, fig. 11, text-fig. 16.

Occurrence. Sanafir, 8.i.49 and 9.ii.49, littoral, growing among rocks.

*Remarks.*The two specimens are typical in the structure of the skeleton but show less of the ramose external form. One of them is low-lying and massive, with occasional ramose portions.

The colour of the two specimens, in formalin, was fawn and brown respectively, in spirit it is now olive-green and brown.

Distribution. Red Sea; Ceylon; Australia (Barrier Reef).

Cacospongia ridleyi, sp. n

Cacospongia cavernosa Ridley, 1884: 590; nec *C. cavernosa,* Autt.

Occurrence. Abu Zabad, 11.ii.49.

Remarks. The name *Cacospongia cavernosa* has been used by many authors for sponges from the Indian Ocean, Mediterranean, and the West Indies. Pallas (1766: 395) appears to have been the first to use the trivial name, but his *Spongia cavernosa* is not recognizable except as one of the Keratosa. Esper's (1794: 189) *S. cavernosa,* based on Pallas's specimen, has been inadequately re-described by Ehlers (1870: 30); and Lamarck's specimen (1813: 371) has been shown by Topsent (1930: 13) to be conspecific with *Ciocalypta penicillus* Bowerbank. Ridley (1884: 590) recorded specimens under *Cacospongia cavernosa* from the Seychelles, and it is with these

that the present specimens are to be identified. *C. ridleyi* agrees closely with *C. cavernosa* Schmidt (as re-described by Schulze, 1879) in external form, but the skeleton has larger meshes and the fibres are more heavily cored with sand-grains and other foreign bodies. It is, however, impossible to say, in the present state of our knowledge, whether the sponges from Seychelles and the Gulf of Aqaba represent a simple variety of the Mediterranean form. As a temporary measure at least they are here given full specific rank.

Distribution. Indian Ocean.

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IV. TURBELLARIA: POLYCLADIDA

By STEPHEN PRUDHOE

THOUGH comprising only three specimens, the collection is an interesting one, since it includes three species which apparently have not been recorded hitherto from the Red Sea.

The condition of the material is satisfactory, and it has been possible to supplement existing descriptions of the three species with some new details of their structure, more especially of the copulatory organs.

Lastly, a brief historical account of the polyclad fauna of the Red Sea is given, together with a list of the species recorded.

PLANOCERIDAE

Planocera crosslandi Laidlaw, 1903

(FIG. 1)

A young adult specimen of this species was found in the fauna associated with coral at Sherm Sheik, 2 February. It measures about 28 mm. in length and about 20 mm. in maximum width, which occurs in the middle region of the body.

FIG. 1. *Planocera crosslandi*. Arrangement of eyes (dorsal view).

 A a

In the structure of the copulatory organs the present specimen agrees very well with the original description of *P. crosslandi*. The posterior region of the cirrus-cavity bears three very large hook-like structures, one of which is attached to the dorsal wall and the others to the subventral walls of the cavity. These structures are directed posteriorly and lie almost entirely in the spacious male antrum.

Planocera crosslandi has been recorded hitherto only from British East Africa.

LEPTOPLANIDAE

Notoplana gardineri (Laidlaw, 1904)

(FIG. 2)

A single individual, provisionally assigned to this species, was found under a rock near the low-tide mark at Sherm Sheik, 15 February. Unfortunately the specimen is damaged, and, as a portion of its hinder region is lost, it is not possible to determine the structure of the female copulatory apparatus.

Transverse serial sections of the copulatory organs of the type-specimen of this species have recently been presented to the British Museum (Natural History) by

FIG. 2. *Notoplana gardineri*. Arrangement of eyes (dorsal view).

Dr. F. F. Laidlaw. The series is incomplete, but, so far as it has been possible to make out, the male copulatory apparatus of the specimen from the Red Sea is indistinguishable, structurally and histologically, from that of the type-material of *N. gardineri* (Laidlaw), a species known hitherto only from Ceylon.

The damaged specimen is somewhat pellucid and measures about 16 mm. in length and about 9 mm. in maximum width. The body is more or less oval in outline. No tentacles have been made out. The eyes are arranged in two elongate groups (Fig. 2). Those in the hinder region of each group are distinctly larger than the remainder and probably represent the tentacular eyes present in other species of *Notoplana*.

The mouth occurs about 10 mm. from the anterior extremity of the body and opens into the hinder region of the pharyngeal chamber. The latter measures about 4·5 mm. in length and contains about 10 pairs of shallow lateral pockets.

The male pore is situated at 3·5 mm. behind the mouth. As is usual in this genus, the ovaries and testes lie in the dorsal and ventral parenchyme respectively. The vasa deferentia unite to open into the proximal end of the arcuate seminal vesicle, which possesses a very thick coat of longitudinal and circular muscle-fibres. This vesicle opens, through the ejaculatory duct, into a well-developed, somewhat pear-shaped prostatic organ lying above the proximal end of the seminal vesicle. The ejaculatory duct projects well into the prostatic organ, the highly glandular epithelium of which completely invests the duct. In this epithelium there are seven elongate pockets, which, together with the ejaculatory duct, open into a small chamber situated in the posterior region of the prostatic organ. From the prostatic chamber a long ductus communis or prostatic canal passes through an extremely thick sheath of muscle-fibres and enters a very small penis-papilla lying in the shallow male antrum. The thick sheath appears to be a continuation of the musculature of the prostatic organ and merges with that of the penis-papilla. There are numerous nuclei present among the muscle-fibres of the sheath, and they seem to congregate more particularly around the prostatic canal.

N. gardineri appears to bear a very close resemblance to *Notoplana otophora* (Schmarda, 1859) which was also originally recorded from Ceylon. According to Stummer–Traunfels (1933), the 'ductus communis' or prostatic canal of the type-specimen of *N. otophora* is invested with a deep layer of parenchymatous tissue enclosed in a thick muscular sheath. On the other hand, in *N. gardineri* the prostatic canal is, as stated above, invested solely with an extremely thick musculature of longitudinal and circular fibres. Nuclei are abundant in this musculature, being particularly dense immediately around the prostatic canal. This difference between the two species might be accounted for by the fact that the type-specimen of *N. otophora* had, when examined by Stummer–Traunfels, apparently been stored in preserving fluid for about seventy years. During this time the tissues of the specimen had, no doubt, undergone some maceration and possibly the histology of the structure through which the prostatic canal passes might originally have been similar to that occurring in *N. gardineri*. In other respects, except possibly in the number of eyes, the two species appear to be identical.

Notoplana cotylifera Meixner, 1907

A single specimen was found in sponges associated with coral at Graa, 30 January. It agrees very well with the description of *N. cotylifera* Meixner, and, as in the original material, a well-developed sucker occurs between the genital pores.

The most striking feature of the female copulatory apparatus in this species is

the pocket-like structure, which Meixner regards provisionally as a rudimentary accessory vesicle, opening into the vagina interna, near the 'shell'-chamber. A somewhat similar structure occurs in the present specimen, but in this instance it appears also to open on the dorsal surface of the body, anteriorly to the female genital pore. Unfortunately the condition of the tissues in this region of the body is not very satisfactory, and the presence of a dorsal opening requires confirmation. If a study of new material were to show that the dorsal opening normally occurred in this species, the accessory structure of the female apparatus would appear comparable with the ductus vaginalis present in some other species of Polyclads.

Notoplana cotylifera has been recorded previously from the Gulf of Tadjoura, French Somaliland, which is, of course, situated near the southern entrance to the Red Sea. Thus the occurrence of this species in the Gulf of Aqaba is not unexpected.

The history of the Polyclad fauna of the Red Sea apparently begins in the year 1826, when the name *Planaria mülleri* was given by Audouin to a planarian figured, but not described, by Savigny in the same year. Two years later (1828) Leuckart described five new forms from Tor in the Gulf of Suez. This work was shortly followed by that of Ehrenberg (1831), in which a further four new species were described from Tor and the Isle of Ras el Gusr. The descriptions of all these ten species are very incomplete, and it does not appear possible to recognize any of the species with certainty.

After 1831 no further species of Polyclads seem to have been recorded from this region until Boutan (1892) mentioned the occurrence of *Pseudoceros violaceus* (Schmarda) at Port Tewfik. Another thirty years elapsed before Meyer (1922) described three new species from Kosseir. Since the appearance of Meyer's work, Palombi (1928) has recorded, among other species, *Idioplana australiensis* Woodworth[1] from the Port of Suez, and Melouk (1940, 1941) has described two new forms from the Biological Station at Ghardaqa.

The results of the sporadic work done since 1826 indicate that our knowledge of the occurrence and distribution of Polyclads in the Red Sea is, in all probability, very incomplete. It may therefore be deemed useful to tabulate the species, including those in the present collection, that have so far been recorded from the Red Sea. The taxonomy of some of the species is very uncertain, and these are marked with an asterisk in the following table:

Species	*Locality*
Cestoplana polypora Meyer, 1922	Kosseir
'*Craspedomata* sp. ?' Palombi, 1928	Gulf of Suez
Cryptophallus aegyptiacus Melouk, 1940	El Ataka & Ghardaqa
**Eurylepta flavomarginata* Ehrenberg, 1831	Ras el Gusr
**Eurylepta praetexta* Ehrenberg, 1831	Tor
Idioplana australiensis Woodworth, 1898	Port of Suez
**Leptoplana hyalina* Ehrenberg, 1831	Tor
[This species, the type of the genus *Leptoplana*, has been regarded by most early writers as a synonym of *Leptoplana tremellaris* (Müller, 1774).]	

[1] Judging from Palombi's description, the material determined by him as *Idioplana australiensis* is probably not identical with that described by Woodworth. In fact, Palombi's material appears to be more closely related to the genus *Idioplanoides* Barbour, 1912, than to *Idioplana* Woodworth, 1898.

Species	*Locality*
Leptoplana nadiae Melouk, 1941	Ghardaqa
Notoplana cotylifera Meixner, 1907	Graa
Notoplana gardineri Laidlaw, 1903	Sherm Sheik
Paraplanocera marginata Meyer, 1922	Kosseir
**Planaria bilobata* Leuckart, 1828	Tor
**Planaria bituberculata* Leuckart, 1828	Tor
**Planaria gigas* Leuckart, 1828	Tor
**Planaria limbata* Leuckart, 1828	Tor
**Planaria mülleri* Audouin, 1826	——
[*P. bituberculata* and *P. mülleri* have been generally regarded as synonyms of *Stylochus suesensis* Ehrbg. If this be accepted, *P. mülleri* has priority over *S. suesensis* and therefore becomes the type-species of *Stylochus* Ehrbg.]	
**Planaria zebra* Leuckart, 1828	Tor
Planocera crosslandi Laidlaw, 1903	Sherm Sheik
Pseudoceros violaceus (Schmarda, 1859)	Port Tewfik
Stylochus coseirensis Bock, 1927 [*nom. nov.* pro *Stylochus reticulatus* of Meyer, 1922]	Kosseir
**Stylochus suesensis* Ehrenberg, 1831	Tor & Port of Suez

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V. GEPHYREA

By A. C. STEPHEN

ROYAL SCOTTISH MUSEUM

THROUGH the courtesy of the British Museum (Natural History), I have had the privilege of examining this collection. It is a small one containing seven individuals, referable to two genera of Sipunculids and one Echiurid. With one exception they have been recorded previously from the Red Sea, the exception being *Siphonosoma koreae* Satô, whose status is discussed.

ECHIURIDAE

Ochetostoma erythrogrammon (Leuckart & Rüppell)

Sherm Sheik, 15.ii.49. Under rock at low tide. One specimen, body 30 mm., proboscis 22 mm.

This species has already been recorded from a number of localities in the Red Sea.

SIPUNCULIDAE

Siphonosoma koreae Satô

Sherm-el-Moiya, 3.ii.49. Associated with coral. One specimen, not fully extended, 115 mm. in length.

A single specimen, which agrees closely with Satô's description (Satô, 1939: 379), was secured. The body is long and thin, pink in colour, and capped at both ends by areas of yellow colour, the posterior area being much less extensive than the anterior area. The body is translucent, the muscle-bands showing through clearly.

The posterior end of the body is somewhat cone-like, and the yellow cap extends for a distance of 5 mm. The introvert is not fully extended, but the yellow area occupies some 20 mm. of the body.

In the specimen described by Satô the colour of the body is given as greyish white.

The skin has numerous papillae, prominent and closely packed on the posterior end and at the base of the introvert, small and scattered on the rest of the body.

Satô described the papillae on the posterior end in his specimen as being less prominent than those on the introvert basis. In this specimen, however, they are of similar size. On the introvert basis the area of prominent papillae extends for about 4 mm.

On the introvert the papillae are small and arranged on circular ridges.

The longitudinal muscle is divided into 19 bands, as in Satô's specimen.

This species was described by Satô from a single specimen taken at Gunzan in Korea on 2 September 1937. In his key and text it is described as being very similar to *S. cumanense* (Keferstein), separable mainly by colour differences, especially the yellow caps, and by the character of the papillae on the basis of the introvert. The

specimen from Aqaba differs from the Korean one in the colour of the body and the greater prominence of the posterior papillae. In view of the somewhat protean nature of *S. cumanense*, with its three well-marked and widely distributed varieties, of which two are common to both the Red Sea and Korean waters, as well as the differences between the two known specimens, it is possible that more material may show that it is not a distinct species but only another variety of *S. cumanense*.

Physcosoma pacificum (Keferstein)

Abu Zabad. 11.ii.49. On reef at low tide. Two specimens. One partially extended, 12 cm. in length. The other similar in size but much contracted. Greyish brown in colour, with scattered darker patches.

Tiran. 10.i.49. Associated with coral. One large specimen; not fully extended, about 13 cm. in length. Uniformly greyish brown in colour with a number of darker bands anteriorly.

Dahab. 3.ii.49. Shore. Two specimens of similar size to the above, but too contracted for measurement. Greyish brown in colour, with scattered darker patches.

This species is widely distributed in the Indo-Pacific area and has already been recorded from the Red Sea.

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VI. MOLLUSCA

By W. J. REES *and* A. STUCKEY

The mollusca are represented by 2 Loricates, 27 Gastropods, 13 Lamellibranchs, 4 Cephalopods, and a few Nudibranchs not reported on here. As this particular area has been thoroughly worked for mollusca by numerous workers, notably McAndrew and Issel, it is not surprising that no new forms were found. The Gastropoda and Lamellibranchia call for no special description and have been listed with notes on distribution. Although the Cephalopoda are all well-known species, they are so well preserved that we have noted features of interest, standard measurements, and included photographs.

Callistochiton heterodon var. *savignyi* appears to be rare and is only known from the northern part of the Red Sea; it was not hitherto represented in the collections of the British Museum. Other species which appear to be confined to the Red Sea are *Clanculus pharaonis*, *Trochus erythraeus*, and *Lithophaga hanleyana*. All the remaining species are found either in the western part of the Indian Ocean or have a wide distribution in the Indo-Pacific. In the Cypraeidae Schilder (1938) has drawn attention to races of well-known species which are becoming differentiated in various areas, including the Red Sea.

The classification of Indian Ocean Lamellibranchs, and indeed all Lamellibranchs, is in a very unsatisfactory state, and in the specific names we have adopted we have followed Thiele (1929–1934), Tomlin (1927), Smith (1897), and various papers by E. Lamy. Recent work on molluscs has shown that species seemingly identical, or appearing to have only minor points of difference, have distinct larvae and life histories, revealing that they are distinct. Elaborate lists of synonyms may therefore prove erroneous, and usually we have confined ourselves to referring the specimens to species with which they appear to be identical.

Among the Cephalopods *Octopus macropus* is common in the Red Sea and in the Mediterranean. The remainder, *O. horridus* Orbigny, *O. cyanea* Gray, and *Sepioteuthis lessoniana* Lesson, are at the western limit of their range, which extends to the Andaman Islands in *O. horridus* and throughout the tropical Indo-Pacific in the other species.

The Cephalopods of the Red Sea have been reviewed by Adam (1942) and a study of his list reveals that they are all either littoral and shallow water forms or have planktonic larvae which live close to the surface during their early life.[1] As examples of the former we have species of *Octopus*, *Sepia*, *Sepioteuthis*, and *Doryteuthis*, and of the latter (oceanic species) we have *Symplectoteuthis*, *Tremoctopus*, and *Argonauta*. Cephalopods characteristic of deep water, and even the Cranchiidae (pelagic species which spend much of their early life in the upper 500 metres), are absent.

It has been pointed out by Thompson (1939) that there is a shallow sill near

[1] We have excluded *Spirula spirula* (L.), the shells of which are recorded from the Red Sea. It is probable that these have their origin outside the area.

Hanish Islands separating the Red Sea 'proper' from the Gulf of Aden. At about latitude 13° 41′ N. the depth of the sill is only 100 metres, and this may act as a geographical barrier to deep-water species. This is probably one reason why bathypelagic forms are absent in the Red Sea, but it does not explain the absence of Cranchiidae, which as larvae often occur right up to the surface. The normal interchange of water over the sill (see Thompson) should carry the larvae into the Red Sea and another explanation is required. There are some grounds for believing that these forms are the young of little known bathypelagic species and they may not be tolerant to high salinities of 38‰ to 40‰ such as are typical of the Red Sea.

The following species are known only from the Red Sea; those marked by an asterisk are insufficiently known and may prove to belong to other species:

Sepia savignyi Blainville, 1827
**Sepia gibba* Ehrenberg, 1831
**Sepia elongata* Férussac & d'Orbigny, 1835–1848
**Sepia trygonina* Rochebrune, 1884
Doryteuthis arabica Ehrenberg, 1831
**Abralia steindachneri* Weindl, 1912
Octopus robsoni Adam, 1941
Sepia dollfusi Adam, 1941

Four of the above are imperfectly known, and of the seventeen species recorded from the Red Sea, only four sound species can be regarded as endemic. It is possible that even this number may be further reduced when the cephalopod fauna of the western Indian Ocean becomes better known.

Class LORICATA

Family Crytoplacidae

Callistochiton heterodon var. ***savignyi*** Pilsbry

Locality: 30.i.49, Mualla, 1 specimen.

This small Callistochiton was taken with two specimens of *Acanthopleura haddoni*. It has a total length of 13 mm. and a breadth of 7·5 mm.

This variety was named by Pilsbry (1892) from a figure given by Savigny (*Egypte*, pl. 3, fig. 8). Our specimen has the following characters. Shell oval, distinctly ridged along the median line; the sides of the valves are only slightly curved. Valves greyish white with occasional irregular darker markings. Girdle buff-coloured with faint slate-grey vertical bands. Head valve, with 10 slightly denticulate ribs, 2 of these bifurcate anteriorly. Tail valve, distinctly narrower than head valve, with 11 radiating rays. Other valves with distinct but not backward projecting beaks. Lateral areas raised with 2 denticulate ribs. Central areas with 7–8 narrow deeply etched riblets on each side with a central smooth tract between them.

This variety has affinities with *C. adenensis* Smith, but differs from it mainly in having only 10–11 radiating ribs on the anterior valve instead of 22 as in Smith's species. *C. heterodon* var. *savignyi* is only known from this northern part of the Red Sea.

Family Chitonidae

Acanthopleura haddoni Winckworth

Acanthopleura sp. Haddon, 1886: 24.
Chiton (*Acanthochites*) *spiniger* Issel, 1819: 235 [non Sowerby].
Acanthopleura spinigera, Sykes, 1907: 34; Tomlin, 1927: 292 [non Sowerby].
Acanthopleura haddoni Winckworth, 1927: 206.

Localities: 29.xii.48, Aqaba, just below low tide mark, 4 adults. 8.i.49, Sanafir, 2 adults. 30.i.49, Mualla, attached or under stones at low tide, 2 adults. 9.ii.49, Sanafir, among rocks along the shore, 1 adult.

This large and decorative chiton is known from the Suez area of the Red Sea under the name *spinigera*. The earliest record is that of Savigny (*Egypte*, pl. 3, fig. 4). Winckworth (1927) distinguishes the species from *A. spinigera* Sowerby, an Australian and Indonesian species, and described specimens from Aden under the name *A. haddoni*. According to Winckworth the living animal reaches a length of 3 in. and our largest specimen is of this size, although it cannot be measured accurately because of contraction of the foot causing the animal to be bent in the form of a crescent. In all our examples the girdle is irregularly marked with black and olive bands. In the living animal the foot is of a salmon-pink colour.

It is impossible at present to give an accurate picture of the distribution of this mollusc. We know it occurs in the Red Sea (at Aden, Suez, and the localities given above), but its occurrence outside this area becomes confused with that of *A. spinigera* (Sowerby). Cyril Crossland (quoted by Sykes) notes that it is 'the common high tide chiton, everywhere in E. Africa, on the cliffs of coral-rag at Djibouti, Mombasa, Zanzibar, Wasin etc.; also on stone on the edge of reefs of the East Coast of Zanzibar'.

Class CEPHALOPODA

Family Loliginidae

Sepioteuthis lessoniana Lesson (Plate 28, figs. 1 and 2; Plate 29, figs. 5 and 6)

31.xii.48, Station A1, dip net, surface, Faraun Island, 1♀(3). 28.i.49, Aqaba, 1♀(1). 4.ii.49, Sanafir, cast net, surface, 1♂(2).

The two specimens are remarkably well preserved, and the ground colour in formalin is flesh-coloured. The reddish-purple chromatophores are fairly evenly distributed over the ventral surface of the head, arms, funnel, and mantle, with denser patches around the edge of the eye. There are no chromatophores on the ventral surface of the fins; the muscle-fibres of the fins are prominent.

On the dorsal surface, the chromatophores are more densely crowded, especially just above the eye, and on the dorsal mantle.

In the male (less prominent in the female) there are irregular ivory-coloured patches which are covered by one or more large chromatophores. When the skin of the mantle is folded back to expose the pen, these white patches are seen to lie over patches of bright emerald-green, which presumably cause the animal to be iridescent. The secondary sexual character of the male (transverse whitish streaks across the dorsal mantle), which has been noted by Adam (1938), is distinct in the

large male from Sanafir (No. 2). Colour notes on the living animal state that the dorsal mantle was of a reddish-brown colour with iridescent green spots on the mantle itself, but not on the fins. The animals appear to fall within the limits given by Adam (1939) in his review of *Sepioteuthis lessoniana*. Adam, and indeed most other workers, have given figures of medium-sized individuals of about 150 mm. in dorsal mantle length. In these the maximum fin width is found in the posterior third of the body, but in our specimens, which are much larger, the maximum fin width occurs about midway between the apex and the mantle margin. This is to be expected in the larger animals because growth proceeds at a much faster rate in the posterior third of the body. As far as can be judged from Adam's illustrations of *S hemprichii* Ehrenberg 1831 our specimens agree in form of the body and in the fins. There appears to be no doubt that Ehrenberg's specimens were really large individuals of *S. lessoniana* like these from the Gulf of Aqaba. The hectocotylized arm (left ventral arm) is particularly well developed and of the usual pattern in *Sepioteuthis*. There are 34 pairs of suckers which gradually diminish in size distally, with a proportionate increase in size of their peduncles. The distal portion of the arm is occupied by 25 pairs of triangular flattened papillae. As noted by Adam (1939) the papillae on the dorsal side are more strongly developed than those on the ventral side.

In the female specimen spermatophores have been deposited on the ventral side of the buccal membrane.

TABLE I

Sepioteuthis lessoniana Lesson

(Measurements in mm.)

	(1) ♀	(2) ♂	(3) ♀
Dorsal mantle length	280	270	136
Ventral mantle length	260	235	127
Greatest mantle length	65	80	35
Greatest mantle thickness	60	63	34
Length of head	39	61	31
Width of head	64	71	36
Thickness of head	45	46	23
Length of fin	258	246	124
Distance between fin base and mantle margin	5	6	6
Arms			
1st right	72	87	30
1st left	69	80	28
2nd right	102	111	47
2nd left	39 (broken)	105	51
3rd right	128	131	58
3rd left	64 (broken)	122	60
4th right	122	136	62
4th left	66 (broken)	134	62
Length, right tentacle	197	214	95
Length, left tentacle	71 (broken)	244	92
Right tentacular club	110	101	40
Left tentacular club	(missing)	116	42
Diameter largest arm sucker	5	5	2·5
Diameter largest tentacular sucker	7	8	4

Sepioteuthis sp. (Plate 29, figs. 3 and 4)

1.ii.49, Sherm Sheik, surface, 1 juvenile. 11.i.49, Sherm Sheik, 1 newly hatched.

The young post-larval squid compares very favourably with one illustrated by Wülker (1913, pl. 22, fig. 2*g*). In our specimen the chromatophores are more numerous than in Wülker's slightly younger specimen. Full measurements of this specimen are given in Table II. We are not able to assign this to any particular species of *Sepioteuthis*, but if we may judge by the extent to which the fins are developed there is every likelihood that it is a young individual of *Sepioteuthis lessoniana* Lesson.

The newly hatched larva has a dorsal mantle length of only 4·5 mm. and is a little damaged. It compares very favourably with a stage illustrated by Wülker in his figure 2*g*.

TABLE II

Sepioteuthis sp.

(Measurements in mm.)

Dorsal mantle length	19
Ventral mantle length	17
Greatest mantle breadth	7
Greatest mantle thickness	6·5
Length of head	7
Width of head	7
Thickness of head	6
Length of fin	12
Distance between fin base and mantle margin	5

Arms	*Right*	*Left*
1st	3·5	3·5
2nd	7	7
3rd	10	10
4th	8	8

Length, right tentacle	16
Length, left tentacle	16
Right tentacular club	7·5
Left tentacular club	7·5
Diameter of largest arm sucker	0·35
Diameter of largest tentacular sucker	0·4

Octopus horridus d'Orbigny (Plate 29, fig. 7)

Octopus horridus d'Orbigny, 1826: 144.
Octopus argus Krauss, 1848: 132.
Polypus aculeatus Hoyle, 1904: 194 [non d'Orbigny 1840].
Octopus (*Octopus*) *horridus*, Robson, 1929: 91.

10.i.49, Tiran, found in coral, 1 ♂.

This littoral octopus is well known from the Suez area of the Red Sea. It has been previously taken in the crevices of coral by Hoyle (1907).

Our specimen agrees in most particulars with earlier descriptions, but a few features are worthy of comment. The dorsal surface of the mantle, head, and arms is ornamental with pale olive-green patches; most of these have a distinct cirrus in the

centre. The spaces in between the paler patches are filled by closely grouped chromatophores, which appear black or very dark red in formalin. There is no ocellus. The ventral surface of the mantle is of a pale cream colour. Colour notes on the living animal state that when found the *Octopus* was yellowish with a green network on the arms. The ground colour changed to brown when the animal was placed on a dark background.

The ground colour of the inner surface of the tentacles is also pale cream with light brown chromatophores evenly distributed over it.

The body is ovoid, the eyes prominent, and the arms long in proportion to the length of the body (the arms are too tightly coiled for accurate measurements, but the formula is of the order 4.3.2.1). The ventral arms are more robust than the others, the first pair being the least well developed. As noted by Robson (1929) the hectocotylized arm is shorter than its fellow. The spermatophore groove on the ventral side is prominent, and is protected especially near its tip by a membraneous extension of the arm.

The standard measurements are given in Table III.

Distribution. This species has been recorded by a number of workers, from the Red Sea, and especially from the Suez Canal zone (see Robson, 1929). Beyond the Red Sea it has been recorded from Ceylon, and other parts of the central Indian Ocean by Hoyle (1904, 1905, 1907*a* and *b*). Other records from the same area are given by Robson (1929: 91). There are no records of this species east of the Andaman Islands.

TABLE III

Octopus horridus d'Orbigny

(Measurements in mm.)

Sex	♂
Total length (including 3rd arm)	65+
Dorsal mantle length	15
Width of body	12
Width of head	11
Arm formula	4.3.2.1
Web formula	$D > C = E > B > A$
Diameter of largest sucker	2·25
Length of ligula	2·55
Indices	
Mantle width index	**80**
Head width index	**13·5**
Sucker index (normal)	**15**

Octopus macropus Risso

11.ii.49, Abu Zabad, on reef at low tide, 1 ♀. 31.xii.48, Station A1, Faraun Island, surface, imm. ♂.

This well-known octopus needs no further description, but standard measurements are provided for comparison with those which already exist for the Caribbean population of this species (Table IV). The measurements indicate that the Red Sea specimens fall within the limits already known for the species.

Distribution. The species occurs in the Caribbean, the NE. Atlantic, the Mediterranean, the Red Sea, and the Indo-Pacific to Japan and Australia. Its eastern limit appears to be the Marshall Islands. It has been recorded from the Red Sea by Wülker (1920) and Weindl (1912), to mention only two records.

TABLE IV

Octopus macropus Risso

(Measurements in mm.)

Sex		♀			juvenile ♂	
Total length (including 3rd arm)		246			40	
Dorsal mantle length		58			16	
Eye to dorsal web		47			6	
Width of body	36	36			10	
Width of head	—	29			7	
Arms	*Right*		*Left*	*Right*		*Left*
1st	246		245	34		34
2nd	228		227	28		26
3rd	208		177	23		22
4th	186		190	20		20
Diameter of largest sucker	—	6			0·75	—
No. of gill filaments		—			11	
Web formula		$B > A > C > D > E$			$B > C = A = D > E$	
Indices						
Mantle width index		**62**			**62·5**	
Head width index		**50**			**44**	
Sucker index (normal)		**10·5**			**4·7**	
Arm length index		**78·5**			**68**	

TABLE V

Octopus cyanea Gray

	I		*II*	
Sex	♀		♀	
Total length (including longest arm)	420		343	
Dorsal mantle length	52		55	
Eye to dorsal web	—		44	
Width of body	46		38	
Width of head	40		35	
Arms		*Right*		*Left*
1st	—	265		205*
2nd	—†	280		190
3rd	—	200*		260‡
4th	—	190‡		210‡
Diameter of ocellus	8		5	
Diameter of largest sucker	6		5	
No. of gill filaments	7–8		9	
Web formula	—		$D = C > B > A = E$	
Arm formula	—		2.1.3.4 or 1.2.3.4	
Web depth	—		47	

* Arm incomplete, tip portion missing. † Arms too tightly coiled for accurate measurements.
‡ Regenerating.

Indices

Mantle with index	**88·5**	**69**
Head width index	**77**	**63·5**
Sucker index (normal)	**11·5**	**9·1**
Arm length index	**82**	**81·5**
Web depth index	**—**	**16·8**

Octopus cyanea Gray (Plate 30)

Octopus cyanea Gray, 1849: 15.
Octopus marmoratus Hoyle, 1886: 227.
Octopus horsti Joubin, 1898: 23.
Polypus fontanianus Robson, 1920: 437.
Polypus horsti, Wülker, 1920: 51.

6.i.49, Sanafir, along shore, 1 ♀. 12.i.49, Sherm Sheik, in shallow water along shore, 1 ♀.

We have referred these two specimens to *Octopus cyanea* Gray, but as they present a different appearance to what is usually associated with *O. cyanea*, the various features worthy of note are discussed below. Typical specimens, of which we have seen a number in the collections of the British Museum, are, as Robson says, 'mainly of a warm ochreous red suffused and maculated with purple, which may be very deep so as to render the animal homogeneously blackish or deep livid (in preservative)'. Our specimens, however, are of a buff or pale brownish colour, with an olive-green sheen, which is especially marked on the dorsal surface of the web and the base of the tentacles. The top of the head, between the eyes, is a deeper brown colour. The specimens are paler ventrally and the ventral side of the arms have the characteristic zebra-like marking which Robson regards as one of the most striking and constantly associated features of *cyanea* as a species. Colour notes made from the living animal state that the colour of the specimen taken on 12.i.49 was brown and that the zebra-like markings on the arms were of a light blue colour.

The dark purple ocellus is well marked and surrounded by an ill-defined pale ring, as mentioned by Robson for his British Museum specimens (Nos. 4 and 8).

Specimen No. I is rather contracted; the skin of the mantle is reticulated and has a number of scattered irregularly arranged cirri, which are more numerous between the eyes and on the fore part of the head. Specimen No. II is less contracted, and has four cirri arranged in a diamond pattern on the dorsal mantle and four to five prominent cirri on the fore part of the head. The ventro-lateral and anterior portion of the mantle carries a number of scattered cirri. There is also a curious fold of skin, on either side of the neck region postero-ventral to the eye, which effectively separates the ventral funnel region from the lateral face of the head.

The dorso-lateral surface of the arms in both specimens have a double row of slightly raised, buff-coloured, simple papillae which have not been mentioned by any other writer. A re-examination of Gray's type of *O. cyanea* and other specimens reveals the presence of these papillae, but they are more difficult to see than in our specimens, because they are obscured by the dark, ground colour normal in this species.

The number of gill filaments in the demi-branchs, normally a good diagnostic feature in octopods, appears to be rather variable in the species (7–9 in our specimens). Robson gives 9–10 for Gray's type of *O. cyanea*, and we have found that even in the same specimen one gill may have 7 filaments and the other 9 filaments per demi-branch (1 ♀ from the Cocos-Keeling Islands).

Standard measurements are given in Table V, but it has not been possible to give measurements of the arms in specimen I because they are too tightly coiled.

The only other ocellate species recorded from this area is *Octopus robsoni* Adam, 1941, of which a complete description has not yet been published. Adam states that this octopod 'se caractérise à première vue par la présence d'une paire d'ocelles pourvue d'un anneau irisé blanchâtre, bleuâtre ou mauve'. We have mentioned this species because our specimens approach nearer to it in colour and the arrangement of the cirri than to the typical form usually found in *O. cyanea*. However, the character of the ocellus, without an iridescent ring, the zebra-like markings on the ventral surface of the arms, and the various indices which fall within the limits of *O. cyanea*, leaves us in no doubt as to the identity of our species.

Distribution. *Octopus cyanea* is a littoral species well known as a reef-inhabiting octopod, with a distribution ranging through the Indo-Pacific in tropical and subtropical waters from Hawaii to the Red Sea.

Previous records from the Red Sea are given by Robson (1929) and Wülker (1920).

Class GASTROPODA

Family HALIOTIDAE

Haliotis varia L.

31.xii.48, station A1, shore of Faraun Island, 3 specimens. 20.i.49, Dahab, on mud flats at low tide, 1 specimen. 5.ii.49, Sanafir, found on coral, 1 specimen. 11.ii.49, Abu Zabad, on reef at low tide, 4 specimens. 15.ii.49, Sherm Sheik, under rocks at low tide, 1 specimen and 1 juvenile. Dahab, found on coral, 1 specimen.

Issel (1869) collected two specimens of *H. varia* from the Gulf of Suez. From the numbers obtained in our collection it appears to be fairly common in the Gulf of Aqaba. According to Pilsbry (1890) it has a wide distribution in the Indo-Pacific, being found in the following places: Australia and Philippines to China; Mozambique, Red Sea, Island of Bourbon, Mauritius, Ceylon, Nicobar Islands, Malay Archipelago.

Family FISSURELLIDAE

Diodora ruppellii (Sowerby)

Fissurella ruppellii Sowerby, 1838: 128.
Fissurella costaria Vaillant, 1865: 109.
Fissurella vaillanti Fischer, 1865: 244.
Glyphis ruppellii, Pilsbry, 1890: 217, pl. 39, fig. 8.
Diodora ruppellii, Tomlin, 1927: 289.

15.ii.49, Sherm Sheik, under rock at low tide, 1 specimen.

Distribution. This molluscs seems to be common almost throughout the Suez

Canal according to Tillier & Bavay. It has frequently been reported at Suez (see Tomlin, 1927, for previous records). *D. ruppellii* is found in the Western Indian Ocean, in the Red Sea, at Aden, Mauritius, and on the East African coast.

Family Patellidae

Cellana rota (Gmelin)

Patella rota, Issel, 1869: 233.
Patella rota, McAndrew, 1870: 444.
Patella variegata Reeve, 1842, pl. 136, fig. 1.
Cellana rota, Tomlin, 1927: 299.

12.i.49, Sherm Sheik, 6 specimens. 20.i.49, Dahab, on mud flats at low tide, 2 specimens.

Both McAndrew and Issel record this species as common; the former from the Gulf of Suez and the latter from the Gulf of Aqaba. Tomlin (1927) found it in the Suez Canal zone.

Distribution. Red Sea, east coast of Africa, Réunion, and Madagascar.

Family Trochidae

Clanculus pharaonis (L.)

30.i.49, Mualla, among rocks and coral at low tide, 1 specimen.

This is one of the most characteristic molluscs of the Red Sea area; it occurs from Suez to Aden, and was reported by Issel (1869) to be especially common in the Gulf of Aqaba. Tomlin (1927) gives previous records for the Suez area and records it from the Canal.

Trochus (Infundibulops) erythraeus Brocchi

20.i.49, Dahab, on mud flats at low tide, 1 specimen. 2.ii.49, Sherm Sheik, associated with coral, 2 fms., 1 specimen.

T. erythraeus has been collected from the Gulf of Aqaba by Issel (1869). Tomlin (1927) recorded it from the Gulf of Suez, and various other collectors, e.g. McAndrew (1870) and Vaillant (1865), have recorded it from the Red Sea area.

Trochus dentatus Forskål

30.i.49, Mualla, among rocks and coral at low tide, 2 specimens. 2.ii.49, Sherm Sheik, associated with coral, 1 young specimen.

T. dentatus is one of the common molluscs of the Red Sea and Persian Gulf. It has been recorded from the Gulf of Suez by McAndrew, Issel, and Vaillant. Tomlin (1927) reports it from the Suez Canal zone, and Issel (1869) states that it is abundant in the Gulf of Aqaba.

Family TURBINIDAE

Turbo radiatus Gmelin

6.ii.49, Sanafir, found in coral, 1 specimen. 11.ii.49, Abu Zabad, on reef at low tide, 2 specimens.

T. radiatus is a common Indo-Pacific form, which is found in the Red Sea, the East African coast, and eastwards as far as the Philippines and New Caledonia. Tillier & Bavay (1905) and Tomlin (1927) record it from the Gulf of Suez and the Suez Canal zone.

Family NERITIDAE

Nerita forskalii Recluz

6.i.49, Sanafir, along shore of anchorage, 3 specimens. 12.i.49, Sherm Sheik, 7 specimens. 30.i.49, Mualla, found at low tide among rocks and coral, 2 specimens.

This extremely variable mollusc has been recorded from the Gulf of Aqaba by Tomlin (1927) and Issel (1869). It is a common Indo-Pacific form, Tryon (1888) giving its distribution as the Red Sea, Indian Ocean, Natal, Singapore, China, the Philippines, and Viti Islands.

Nerita undata var. ***quadricolor*** Gmelin

12.i.49, Sherm Sheik, 1 specimen.

N. undata is a widely distributed species in the Indo-Pacific. In the variety *quadricolor* the aperture of the shell is white and the ribs are maculated with purplish black. This variety is confined to the western part of the Indian Ocean.

Family PLANAXIDAE

Planaxis breviculus Deshayes

6.i.49, Sanafir, along shore of anchorage, 3 specimens.

This species has been reported from the Gulf of Suez by McAndrew (1870), who records it as a common species at low water. Smith (1891) reports it from Aden and refers to specimens in the British Museum from the Gulf of Aqaba and Persian Gulf. According to Tryon (1887) *P. breviculus* is a variety of *P. sulcatus*. Both forms have a wide distribution in the Indo-Pacific. Until more is known about the life-history of these periwinkles, we prefer to retain the name *P. breviculus*.

Family CERITHIIDAE

Cerithium tuberculatum (L.)

6.i.49, Sanafir, shore of anchorage, 2 specimens.

McAndrew found this species moderately common in the Gulf of Suez. It is an extremely variable species, and has been reported on numerous occasions from the Red Sea.

Distribution. Widespread in the Indo-Pacific (Smith, 1903).

Family Melanellidae

Melanella sp.

10.i.49, Tiran, 1 specimen.

We do not feel justified in giving this specimen a name in view of the confusion which exists in the classification of the genus.

Family Strombidae

Pterocera lambis (L.)

5.ii.49, Sanafir, in coral, 1 specimen.

This large shell was previously recorded from the Gulf of Aqaba by Issel (1869).
Distribution. Widespread in the Indo-Pacific.

Family Naticidae

Natica mamilla L.

N. mamilla, Lamarck, 1838: 630.

6.i.49, Sanafir, along shore of anchorage under rocks, 1 specimen.

N. mamilla has been previously recorded from the Gulf of Aqaba by Issel (1869). Tryon (1886) gives the distribution as the East Indies, the Philippines, New Caledonia, and central Polynesia.

Family Cypraeidae

Cypraea caurica (L.)

20.i.49, Dahab, on mud flats at low tide, 1 young specimen.

Schilder (1938) recognizes seven races of this species, which has a widespread distribution in the Indo-Pacific.

Cypraea arabica L.

30.i.49, Mualla, among rocks and coral at low tide, 1 specimen. 5.ii.49, Sanafir, found in coral, 1 juvenile specimen. 11.ii.49, Abu Zabad, on reef at low tide, 1 specimen. 11.ii.49, Abu Zabad, on reef at low tide, 4 juvenile specimens.

C. arabica is a well-known Indo-Pacific species, often recorded by workers on Red Sea fauna. Savigny (*Egypte*) gives a figure, and the species is recorded from the Gulf of Aqaba by Issel (1869). Schilder (1938) recognizes six races in the Indo-Pacific; our specimens conform to the E. African and Red Sea form which Schilder calls *immanis*.

Cypraea isabella L.

Turia (*Basilitrona*) *isabella*, Schilder, 1938: 176.

3.ii.49, Sherm-el-Moiya, associated with coral, 1 specimen. 6.ii.49, Sanafir, associated with coral, 1 specimen.

C. isabella, of which four races are recognized by Schilder, has a widespread distribution in the Indo-Pacific. Our specimens belong to the typical form which is confined to the Western Indian Ocean and the Red Sea.

Cypraea carneola L.

Cypraea (*Lyncina*) *carneola*, Schilder, 1938: 188.

11.ii.49, Abu Zabad, on reef at low tide, 3 specimens. 11.ii.49, Abu Zabad, on reef at low tide, 2 juvenile specimens.

This species is widely distributed in the Indian Ocean and also in the Pacific as far as Hawaii. Schilder recognizes four races of this species. The Red Sea form *crassa* is also found in the Gulf of Aden, Persian Gulf, and Karachi.

Cypraea erosa L.

Erosaria (*Erosaria*) *erosa*, Schilder, 1938: 137.

30.i.49, Mualla, among coral at low tide, 1 specimen.

This species has been recorded from the Gulf of Aqaba by Issel (1869). *C. erosa* has a wide distribution in the Indian Ocean and in the Western Pacific. Our specimen belongs to the typical form. Schilder (1938: 137) recognizes six races in the Indo-Pacific.

Cypraea tigris L.

Cypraea (*Cypraea*) *tigris*, Schilder, 1938: 186.

11.ii.49, Abu Zabad, on reef at low tide, 1 immature specimen.

Issel (1869) reports this species to be abundant in the Gulf of Aqaba. It has previously been reported from the Red Sea by many writers, including Ehrenberg (1831). Our specimen is not fully grown and we are unable to determine whether it belongs to the typical form. *Cypraea tigris* (*sensu lata*) is widely distributed in the Indian Ocean and in the Pacific.

Family Cymatiidae

Cymatium rubeculum (L.)

Tritonium (*Simpulum*) *rubeculum*, McAndrew, 1870: 434.
Triton (*Simpulum*) *rubecula*, Tryon, 1881: 12.

1.ii.49, Sherm Sheik, associated with coral, 2 specimens.

McAndrew took 2 specimens at Jubal Island in the Gulf of Suez.
Distribution. Red Sea to the Philippines.

Distortrix anus (L.)

Triton anus, Reeve II, *Triton*, pl. xii, fig. 63.

Abu Zabad, on reef at low tide, 1 specimen.

This species has been previously recorded from the Gulf of Aqaba by Issel (1869).

Family Muricidae

Drupa (Drupa) ricinus (L.)

30.i.49, Mualla, among rocks and coral at low tide, 4 specimens. 11.ii.49, Abu Zabad, on reef at low tide, 1 specimen.

Distribution. Red Sea, east coast of Africa, to Natal, Philippines, and Polynesia (Tryon, 1880: 184).

Drupa (Drupa) elata (Blainville)

2.ii.49, Sherm Sheik, 2 fms., associated with coral, 3 specimens.

This well-known inhabitant of coral reefs has a wide distribution in the Indo-Pacific. It is recorded from Aden by Smith (1891).

Family Buccinidae

Pisania ignea Gmelin

2.ii.49, Sherm Sheik, 2 fms., 1 specimen. 5.ii.49, Sanafir, found in coral, 1 specimen.

Distribution. Red Sea, Singapore, and Philippines.

Family Conidae

Conus rattus Lamarck

Conus rattus, Smith, 1891: 399.
Conus rattus, Dautzenberg, 1937.

Conus rattus is a very variable species and has been recorded by many authorities including Smith (1891) and Dautzenberg (1937). Its distribution is very widespread in the Indo-Pacific.

Conus textile L.

11.ii.49, Abu Zabad, on reef at low tide, 1 specimen.

This poisonous cone shell is widely distributed in the Indo-Pacific and has been recorded from the Gulf of Aqaba by Sturany. Dautzenberg (1937) gives a very long list of localities for the species.

Family Nassidae

Nassa pulla L.

20.i.49, Dahab, collected on mud flats at low tide, 5 specimens.

Issel (1869) records this shell from the Red Sea area. Tryon (1882) gives its distribution as the Red Sea, Java, and the Philippines.

Class *LAMELLIBRANCHIA*

Family Arcidae

Arca divaricata Sowerby

Arca divaricata, Tomlin, 1927: 304.

2.ii.49, Sherm Sheik, associated with coral, 2 fms., 2 specimens. 15.ii.49, Sherm Sheik, under rocks at low tide, 3 specimens.

It has previously been recorded by Tomlin from the Suez Canal and by McAndrew from the Gulf of Suez, under the name *A. plicata*. *A. divaricata* has a wide distribution in the Indian and Pacific Oceans.

Arca (Barbatia) decussata Sowerby

31.xii.48, station A1, shore of Faraun Island, 1 specimen. 31.xii.48, station A1, shore of Faraun Island, 2 specimens. 20.i.49, Dahab, mud flats at low tide, 4 specimens. 30.i.49, Mualla, among rocks and coral at low tide, 1 specimen. 9.ii.49, Sanafir, among rocks on shore, 1 specimen.

This species is known from the following places, according to Lamy (1917), Djibouti, Obock, Perim, and Aden. It is expected to have a much wider distribution, and we note a specimen in the British Museum collections from the Java Sea (off Batavia).

Family Mytilidae

Brachidontes variabilis (Krauss)

Mytilus variabilis Krauss, 1848: 25.
Mytilus pharaonis Tillier and Bavay, 1905: 177.
Mytilus exustus, Vaillant, 1865: 114.

20.i.49, Dahab, on mud flats at low tide, 1 specimen.

This very common species was first described from Table Bay by Krauss, who drew attention to its similarity to specimens from the Red Sea. The earliest record from the latter locality is that of Savigny (*Egypte*, pl. xi, fig. 5).

Lithophaga hanleyana Reeve

31.i.49, Mualla, associated with coral, 2 specimens.

L. hanleyana has been previously recorded from the Gulf of Aqaba by Sturany (1899), who also recorded it from the Gulf of Suez and the Red Sea generally. It has also been recorded from the Gulf of Suez by Reeve and McAndrew. The Cambridge expedition to the Suez Canal (1924) also took the species in association with coral.

Lithophaga moluccana Hanley

14.ii.49, Dahab, associated with coral, 1 specimen.

We have identified this species with Hanley's species from Malacca. It appears

to differ from *L. hanleyana* (which is already known from the Red Sea) by the more tapering posterior part of the shell.

Distribution. Indian Ocean.

Family VULSELLIDAE

Vulsella vulsella (L.)

V. lingatula, Issel, 1869: 99.
V. mylitina, Issel, 1869: 100.
V. trita Reeve, 1858, pl. 2, fig. 17.

14.ii.49, Dahab, associated with coral, 1 specimen.

Smith (1911), who has reviewed the genus, gives the distribution of this species as widespread in the Indian Ocean and eastwards to Japan, N. Australia, and New Caledonia. From the Red Sea it has been figured by Savigny (*Egypte*, pl. xiv, figs. 1 and 2) Rüppell records it as *mytilina* and Reeve as *trita*, both from the Red Sea.

Family PECTINIDAE

Chlamys luculentus (Reeve)

Pecten luculenta Reeve, 1853, pl. 16, fig. 59.

2.ii.49, Sherm Sheik, 2 fms., associated with coral, 1 specimen.

We have compared this specimen with the holotype of Reeve from NW. Australia and also with some specimens in the British Museum collection from Aden. There are no differences to be noted in our shell.

The known distribution is the Red Sea and Indian Ocean.

Family OSTREIDAE

Ostrea cucullata Born

9.ii.49, Sanafir, among shore rocks, 1 specimen.

O. cucullata is a very variable species and had been recorded from the Gulf of Suez by Vaillant (1865) and by Issel (1869). This oyster is edible and according to Jousseaume, as quoted by Lamy (1925), is an excellent purgative.

Distribution. Very common at many points in the Red Sea, attached to rocks, which are uncovered by the tide. This species is common throughout the Indian Ocean, and in the Pacific as far as Japanese waters (Lamy, 1925).

Family CARDITIDAE

Cardita variegata (Sowerby)

Cardium variegatum Sowerby, 1841: 107.
Cardita subaspersa Lamarck, 1819: 25.
Cardita radula Reeve, 1843: 191.

11.ii.49, Abu Zabad, on reef at low tide, 4 specimens.

C. variegata is widespread in the Indo-Pacific, Red Sea, and Australian waters. Lamy (1916) records it from Suez, Massaouah, Djibouti, and Perim.

Family TRIDACNIDAE

Tridacna noae (Röding)

Tridacnes noae Röding, 1798: 171.
Tridacna elongata Lamarck, 1819: 106.

31.xii.48, shore of Faraun Island, 2 specimens.

This *Tridacna* has been recorded from the Red Sea, from Suez, and the Gulf of Aqaba by Issel (1869) under the name *T. elongata* Lamarck. Savigny gives the earliest figure from this area (*Egypte*, pl. x, fig. 1). It has a wide range in the Indo-Pacific, including Zanzibar, Mauritius, Australia, Solomon Islands, Carolines, Marshall, and Loo Choo Isles (McLean, 1947).

Tridacna squamosa Lamarck

One specimen of this common Indo-Pacific form was collected; the label appears to have been lost.

Distribution. Indian Ocean, Indonesia, Australia, the Philippines, and Japan.

Family VENERIDAE

Circe scripta (L.)

Venus scripta L.

20.i.49, Dahab, mud flats at low tide, 1 specimen.

Sowerby gives the distribution of this as the Red Sea and Australia. According to Issel (1869) it is a rare species at Suez.

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Legends to Plates 28–30

PLATE 28. *SEPIOTEUTHIS LESSONIANA* LESSON

FIG. 1. Ventral view of ♀ caught at the surface off Faraun Island, 31.xii.48.

FIG. 2. Dorsal view of ♂ caught off Sanafir Island, 4.ii.49.

The transverse streaks characteristic of the male and the pale areas overlying the iridescent patches are clearly shown in the photograph.

PLATE 29

FIGS. 3 and 4. *Sepioteuthis* sp.; dorsal and ventral views of a young immature specimen taken off Sherm Sheik, 1.ii.49.

FIG. 5. *Sepioteuthis lessoniana* Lesson; left tentacle club of ♀ shown on Plate 28, fig. 1.

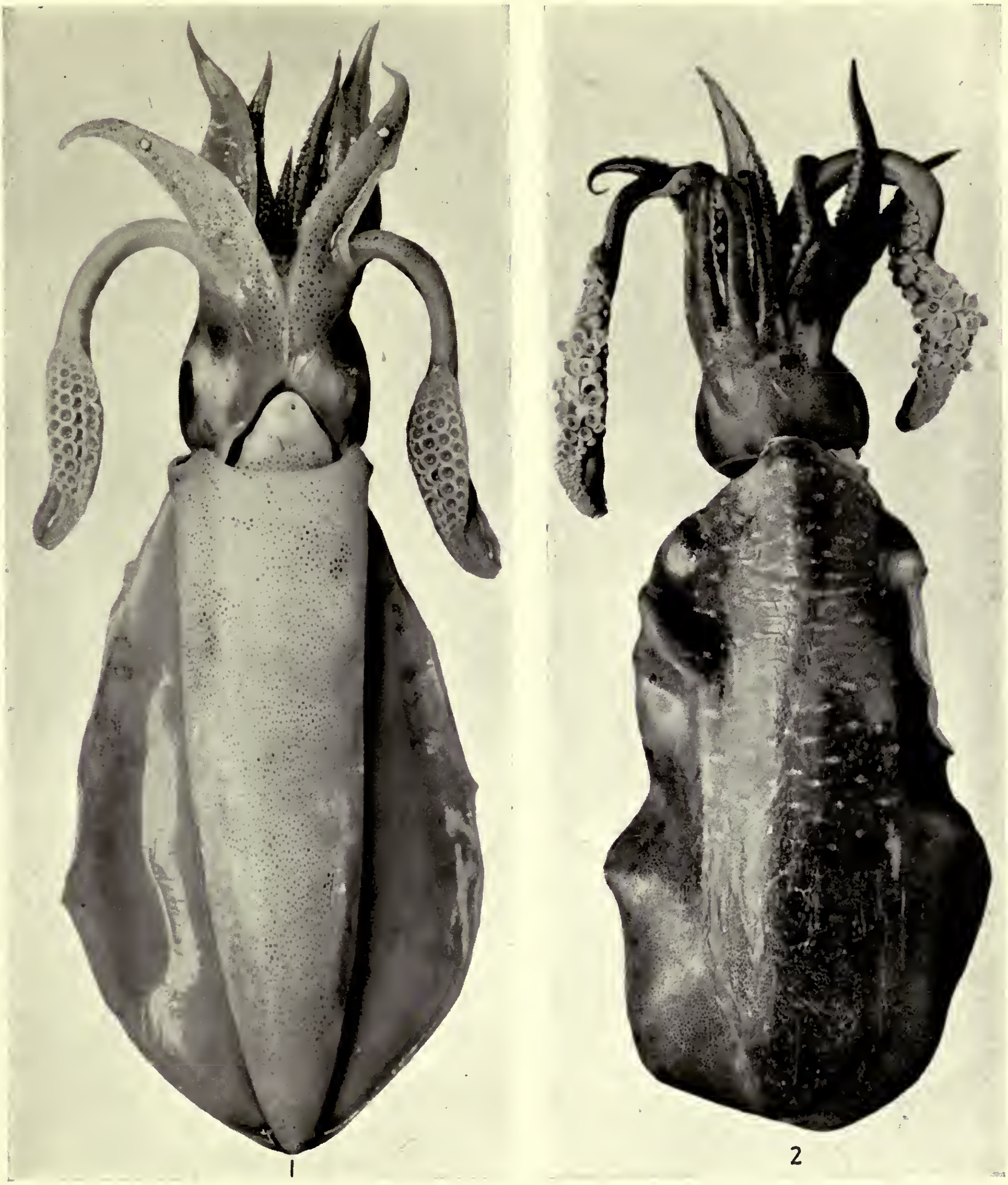
FIG. 6. *Sepioteuthis lessoniana* Lesson; right tentacle club of ♀ taken at Aqaba, 28.i.49.

FIG. 7. *Octopus horridus* Orbigny taken at Tiran Island, 10.i.49.

PLATE 30. *OCTOPUS CYANEA* GRAY

FIG. 8. Lateral view of a ♀ taken at Sherm Sheik, 12.i.49.

FIG. 9. Oral face of the same specimen as in Fig. 8. The so-called 'zebra' markings on the lateral side of the arms are a constant feature in this species.



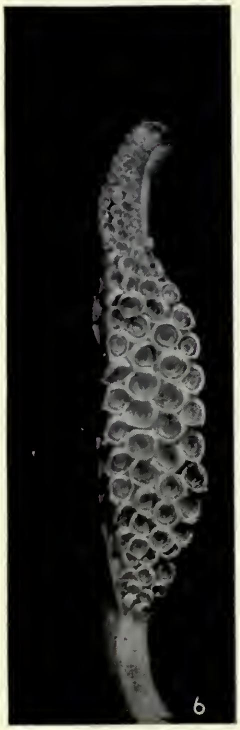
SEPIOTEUTHIS LESSONIANA LESSON


7


5


3


4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AQABA CEPHALOPODA

8

9

OCTOPUS CYANEA GRAY

VII. ECHINODERMATA

By AILSA M. CLARK

THE collection of Echinoderms includes many well-known littoral species which are widespread throughout the Indo-West Pacific area, as well as some which are peculiar to the Red Sea. A few species, notably the single Crinoid *Capillaster multiradiata* (Linnaeus) and an Echinoid, *Clypeaster fervens* Koehler, have not been previously recorded from the Red Sea.

The species are the following, all of them from low tide or low spring tide level except where otherwise stated. Those mentioned in more detail in the text are marked with an asterisk. References in the text giving further details are marked with a dagger.

	Locality	*Number*
ASTEROIDEA		
Astropecten polyacanthus Müller & Troschel .	Dahab	1
	Ras Muhammad Bay	1
**Fromia ghardaqana* Mortensen	Dahab	1
	Abu Zabad	3
**Gomophia egyptiaca* Gray	Abu Zabad	1
Linckia multifora (Lamarck)	Sherm Sheik	2
	Dahab	1
	Sanafir I.	1
Asterope carinifera (Lamarck)	Abu Zabad	2
**Asterina burtonii* Gray	Sanafir I.	1
	Dahab	1
	Sherm Sheik	1
	Abu Zabad	4
OPHIUROIDEA		
**Ophiocoma pica* Müller & Troschel . . .	Dahab	5
	Sherm Sheik	4
	Sanafir I.	5
	Mualla	1
	Tiran	3
	Abu Zabad	5
**Ophiocoma scolopendrina* (Lamarck) . .	Sanafir I.	3
	Dahab	8
	Faraun Id.	10
	Sherm Sheik	4
	Abu Zabad	2
**Ophiocoma erinaceus* Müller & Troschel . .	Dahab	2
	Sherm Sheik	1
	Sanafir I.	2
	Abu Zabad	2
Ophiocoma valenciae Müller & Troschel . .	Tiran	4
	Sanafir I.	1
	Sherm Sheik	1
	Abu Zabad	2
	Dahab	1
**Ophiocoma* sp.	Sherm Sheik	1
**Macrophiothrix hirsuta* (Müller & Troschel) .	Sherm Sheik	1
	Sanafir I.	1
	Dahab	2

	Locality	Number
Ophiotrichoides propinqua (Lyman)	Dahab	2
**Placophiothrix purpurea* (von Martens)	Dahab	1
Ophiolepis cincta Müller & Troschel	Dahab	5
	Abu Zabad	2
	Sherm Sheik	3

CRINOIDEA

**Capillaster multiradiata* (Linnaeus)	Dahab	1

ECHINOIDEA

Eucidaris metularia (Lamarck)	Sherm-el-Moiya	1
	Mualla	2
	Sherm Sheik	8
	Sanafir I.	2
	Tiran	7
Diadema setosum (Leske)	Aqaba	2
	Sherm-el-Moiya	1
	Tiran	1
	Faraun I.	1
	Abu Zabad	1
Echinometra mathaei (Blainville)	Mualla	1
	Abu Zabad	4
	Sherm Sheik	4
	Tiran	5
	Sanafir I.	4
	Dahab	10
Heterocentrotus mammillatus (Linnaeus)	Dahab	3
**Tripneustes gratilla* (Linnaeus)	Abu Zabad	3
	Sanafir I.	1
	Dahab	6
	Aqaba	2
Clypeaster humilis (Leske)	Dahab	1
**Clypeaster fervens* Koehler	Dahab	1
Lovenia elongata (Gray)	Dahab	1

HOLOTHUROIDEA

Synapta maculata (Chamisso & Eysenhardt)	Um Nageila (in shallow water off mangrove swamp)	1
Synaptula recta (Semper)	Sherm Sheik	1 (pt.)
Halodeima edulis (Lesson)	Dahab	1
	Abu Zabad	1
Halodeima atra (Jäger)	Abu Zabad	2
Halodeima cinerascens (Brandt)	Abu Zabad	1
Holothuria impatiens (Forskål)	Dahab	5
**Holothuria sucosa* Erwe	Dahab	1
Holothuria pardalis (Selenka)	Dahab	5
	Graa	2
Holothuria curiosa var. *pervicax* (Selenka)	Dahab	1
Microthele difficilis (Semper)	Abu Zabad	8
	Dahab	6
**Microthele nobilis* (Selenka)	Ras Muhammad Bay	1
Actinopyga miliaris (Quoy & Gaimard)	Faraun I.	1

ASTEROIDEA

Family LINCKIIDAE

Fromia ghardaqana Mortensen

PL. 31, FIGS. *a–c*

Scytaster milleporellus, Müller and Troschel, 1842: 35; [non *Asterias milleporella* Lamarck, 1816: 564].
Fromia milleporella (part), Gray, 1866: 14.
Fromia monilis, Tortonese, 1935: 70; 1936: 213; [non *Fromia monilis* Perrier, 1875: 443 (p. 179 in repaged edition)].
Fromia ghardaqana Mortensen, 1938: 37.

Dahab, shore; 1 specimen. Abu Zabad, reef at low water springs; 3 specimens.

Description. R = 40 mm., r = 10 mm., R/r = 4·0. The arms taper evenly throughout their length to a rather pointed tip. One has been broken and is in process of regeneration. Of the five primary inter-radial plates, three are enlarged with a flat surface raised slightly above the level of the surrounding plates, the one adjacent to the madreporite is smaller but also a little elevated, while the fifth is not at all conspicuous. The madreporite is triangular in shape, with deep radiating grooves, and measures 1·4 mm. across.

The carinal row of plates is not very clear proximally, where all the plates are in fact rather irregularly arranged. At the base of the arm there are about seven plates across the width.

All the dorsal and ventral plates, as well as the marginals, are closely covered with uniform, smooth, rounded granules, about 7 in the length of 1 millimetre. These lie very close together and are polygonal on the convex plates, of which there are about 10 on the dorsal side of each arm, besides the primary inter-radial plates and the marginals. Most of the convex plates are near the tip of the arm, but an irregular series of spaced plates occupies the mid-radial distal area.

The number of supero-marginal plates varies between 19 and 21 on the four complete arms, with the same number in each infero-marginal series. The latter plates are relatively narrower and are noticeably longer than broad. In the distal half of the arm they may bear a small tubercle in the centre as also do the last two supero-marginals. These plates, unlike the infero-marginals, are not evenly sized but, especially distally, large and small plates tend to alternate with one another, the larger ones being rather convex. The two series of marginal plates tend to alternate in position.

On the ventral side the papulae are clearly visible in the angles between the plates. The granules surrounding each one are not markedly larger than the other granules. Proximally there are 3 rows of papulae, correlated with the presence of 4 rows of ventro-lateral plates. The outermost row of these consists of only 4 plates on each side of the interbrachial angle, extending to the aboral end of the second infero-marginal plate. The third series reaches the seventh infero-marginal, the second to the eleventh plate, and the innermost series to the fourteenth.

The adambulacral plates bear 2, or, in the middle part of the arm, often 3 flattened furrow spines. Outside these is a single stumpy spine, shorter than the furrow spines though much thicker and slightly elongated in transverse section. On both sides of this spine and outside it are numerous granules like those of the ventro-lateral plates.

Remarks. Müller and Troschel's description of *Scytaster milleporellus* together with the locality of the Red Sea suggests that their specimens like many of Gray's were almost certainly *Fromia ghardaqana.* However, some of the latter, from Mauritius and other localities in the Indian Ocean, are the form (pl. 31, fig. *d*) with even-sized supero-marginal plates which is generally assumed to represent *Fromia milleporella.* Since Lamarck gave as the type locality 'les mers d'Europe?', and only a brief description, it is not certain which form really is *milleporella.* This question can only be answered by study of the type specimens if they are still in existence.

Mortensen has examined the type of *Fromia monilis* Perrier and finds it quite distinct from the Red Sea species, although he does not give any details.

On comparison of the specimen described with one of *F. monilis* from Macclesfield Bank, South China Sea, with R = 35 mm., it is at once seen that the granulation of the dorsal side of the latter is very much finer with at least 10 granules to a millimetre rather than only 7. Also the arms of *F. monilis* are relatively much narrower with R/r about 4·5 on average and the supero-marginal plates usually occupy more of the dorsal surface of the arm, so that only 3 or 5 rows of plates, rarely more, lie across the base of the arm. On the ventral side the granules around the pores are clearly enlarged unlike those of *F. ghardaqana.*

Unfortunately there are no specimens of *Fromia pacifica* H. L. Clark (the species that Mortensen says is most nearly related to *F. ghardaqana*) in the British Museum to compare with the material from the Red Sea. That Torres Strait species apparently has even-sized supero-marginal plates and pointed granules rather than flat ones.

There are also three juvenile specimens in the present collection, the two larger ones having R = 18 mm., but whereas one is much more slender with an R/r ratio of 3·5:1, the other has the ratio only 2·8. Of the many old dry specimens in the British Museum, the R/r value varies between 3·0 and 3·7, although a co-type of *F. ghardaqana* from Ghardaqa sent by Dr. Mortensen has the ratio 4·0. This it seems is just about the maximum value.

From all the other species of *Fromia, F. ghardaqana* is easily distinguished by the alternate large and small distal supero-marginals.

Gomophia egyptiaca Gray

Pl. 32

Gomophia egyptiaca Gray, 1840: 286. H. L. Clark, 1921: 55.
†*Scytaster aegyptiacus,* Perrier, 1875: 428 (p. 164 in re-paged edition).
Nardoa aegyptiaca, de Loriol, 1891: 30. Fisher, 1906: 1087. Koehler, 1910: 157, pl. xvii. 5, 6.

Abu Zabad, reef at low water springs; one specimen.

R = 84 mm., while the type has R = 62 mm. The intermarginal plates in the arm angle are not more conspicuous than in the type and indeed are quite hidden by the granulation in one of the angles.

Range. Red Sea, Mauritius, Samoa, Philippines, Fiji, Macclesfield Bank.

Family ASTERINIDAE

Asterina burtonii Gray

Asterina burtonii Gray, 1840: 289. †G. A. Smith, 1927: 641.
Asteriscus wega Perrier, 1869: 102.
Asterina wega Perrier, 1876: 238 (p. 318 of re-paged edition).

Sanafir; one specimen. Dahab; one 6-armed specimen. Abu Zabad; 4 specimens. Sherm Sheik; one 7-armed specimen.

Remarks. Since in 1876 Perrier corrected the error in his original description of *A. wega*, regarding the number of spines on each ventro-lateral plate, emending it to 2 or 3 rather than 1, there seems to be no reason why specimens with up to 8 arms should not be regarded as *Asterina burtonii*. Smith accepts 6-armed specimens as such. These forms with more than 5 arms are usually juvenile and more or less obviously in process of regeneration. The 7-armed specimen in the present collection has 4 arms diminutive. Perrier states that all his thirteen specimens of *A. wega* were undergoing regeneration.

2. OPHIUROIDEA

Family OPHIOCOMIDAE

Ophiocoma pica Müller & Troschel

Ophiocoma pica Müller & Troschel, 1842: 101. H. L. Clark, 1921: 127, pl. xiii, 8 (coloured). †Ely 1942: 54, pl. xii, B.i., text-fig. 15.
Ophiocoma lineolata Müller & Troschel, 1842: 102. de Loriol, 1893: 28.

Dahab; 5 specimens. Sherm Sheik; 4 specimens. Sanafir; 5 specimens. Mualla; 1 specimen. Tiran; 3 specimens. Abu Zabad; 5 specimens. All from coral at low tide.

Remarks. These specimens are easily distinguished from the other Ophiocomas collected by the conspicuous stripes on the otherwise black arms and the yellowish stripes on the disk. The ratio of arm length to the disk diameter varies between 3·6 and 4·8: 1.

Note. It has been accepted for a very long time that *O. pica* and *O. lineolata* are synonymous, but both names have been retained by different authors. For instance Koehler (1922*a*: 324) still uses *lineolata* although most other recent authors prefer *pica*. However, the latter name had page priority in Müller & Troschel's *System der Asteriden*. So in spite of its previous use in manuscript by Valenciennes, which has no validity, the name *Ophiocoma lineolata* should be dropped.

Ophiocoma scolopendrina (Lamarck)

Ophiura scolopendrina Lamarck, 1816, **2**: 544.
†*Ophiocoma scolopendrina*, de Loriol, 1893: 23. H. L. Clark, 1921: 125, pl. xiii. 9. †Koehler, 1922*a*: 325, pls. lxxiii. 5; lxxiv. 1–7.

Sanafir; 3 specimens. Dahab; 8 specimens. Faraun Island; 10 specimens. Sherm Sheik; 4 specimens. Abu Zabad; 2 specimens. All from the shore under stones.

Remarks. The colour ranges from variegated bluish grey to dense black on the dorsal side of the disk and arms, the ventral side of the disk being always pale. Most have the arms broken but they are usually relatively long, six or more times the disk diameter.

Ophiocoma erinaceus Müller & Troschel

Ophiocoma erinaceus Müller & Troschel, 1842: 98. †de Loriol, 1893: 21. H. L. Clark, 1921: 127. †Ely, 1942: 52, text-fig. 45, pl. xii*a*.

Dahab: 2 specimens. Sherm Sheik; 1 specimen. Sanafir; 2 specimens. Abu Zabad: 2 specimens.

Remarks. Except for the two specimens from Abu Zabad, these are densely black all over; even the tentacles of those from Dahab are black; also the arms are relatively short, the ratio of arm length to disk diameter being 4–4·8:1. The Abu Zabad specimens are also densely black dorsally but are pale on the underside of the disk, although the tentacles are black. The arms of one are all broken but in the other their length is nearly seven times the disk diameter. They are thus intermediate between *O. scolopendrina* (with relatively long arms and lighter colour) and *O. erinaceus*, with shorter arms and a uniformly dark colour, so there was some doubt as to which species they should be. Finally they were referred to the latter species for the following reasons: besides the very dense black colour on the dorsal side, the disk granulation hardly extends below the periphery and there are two tentacle scales for quite a large part of the arm, as in *erinaceus*. Also, apart from these morphological characters, the fact that they were taken well out on the reef at low spring tide level in the same zone as *Ophiocoma pica* suggests that they belong to *erinaceus*, for H. L. Clark makes the distinction of habitat of the two forms *scolopendrina* and *erinaceus* an important reason for maintaining them as separate species, the former characteristically occupying a higher level on the shore which is uncovered at ordinary low tides.

I fully agree with Ely that very rarely can several characters be used to distinguish intermediate specimens as belonging to one or the other species. Quite often conflicting results are obtained by using two different characters. For instance there is a specimen in the British Museum collection from Muscat, with the proportions 170 mm./21 mm. = 6·4:1, which would on this count be called *scolopendrina*, but the unrelievedly black colour on the contrary suggests that it is *erinaceus*. In such cases only a detailed observation of the habit and habitat can produce a conclusive identification.

Ophiocoma sp.

Sherm Sheik; 1 specimen.

This is a very small specimen (disk diameter = 5 mm.) with all the arms broken and a hole through the centre of the disk. It is nearest to *O. pica* as there are 2 tentacle scales, 5 slender arm spines proximally, and dark bands on the arms, also the oral shields are longer than wide. However, the dorsal side of the disk is unusual in having black spots each surrounded by a lighter ring on a dark brown background. These spots vary in size and shape but are relatively much larger than those of *Ophiocoma döderleini*.

Family Ophiotrichidae

Placophiothrix purpurea (von Martens)

Ophiothrix purpurea von Martens, 1867: 346. Döderlein, 1896: 296, pls. xiv. 12; xvii. 23.
†*Ophiothrix lepidus* de Loriol, 1893: 45, pl. xxv. 1.
†*Ophiothrix fallax* de Loriol, 1893: 47, pl. xxv. 2.
Placophiothrix purpurea, H. L. Clark, 1939: 86.

Dahab; 1 specimen.

This specimen agrees very closely with de Loriol's description of *Ophiothrix fallax* from Mauritius, as it has a pale green disk and relatively long arms (disk diameter = 4·5 mm., arm length = 45 mm.). H. L. Clark has declared *O. lepida* de Loriol to be a synonym of *O. purpurea*, from a study of the long series of specimens obtained by the John Murray Expedition. He makes no mention of *O. fallax*, but as the characters of that species are intermediate between those of the other two, it certainly comes within the range of variation of *Placophiothrix purpurea*.

Possibly Döderlein's *Ophiothrix lorioli* (1896: 297) from Amboina, with radial shields similar to those of *O. lepida*, is also a synonym of *purpurea*. Both Döderlein and Koehler (1898: 102) say that *O. lepida* and *O. lorioli* cannot be confounded, but neither of them give any reason for this.

Macrophiothrix hirsuta (Müller & Troschel)

Ophiothrix hirsuta Müller & Troschel, 1842: 111. Marktanner-Turneretscher, 1887: 311. †Koehler, 1922*a*: 234, pls. xxxi. 1, 2; xxxiii. 13; xcix. 2. Tortonese, 1949: 37.
Ophiothrix cheneyi Lyman, 1861: 84.
Macrophiothrix hirsuta, H. L. Clark, 1938: 285.
Ophiothrix demessa, H. L. Clark, 1939: 83. [non *Ophiothrix demessa* Lyman, 1861: 82.]

Sherm Sheik; 1 specimen. Sanafir; 1 specimen. Dahab; 2 specimens.

Remarks. There seems to be considerable difference of opinion as to the shape of the dorsal arm-plates in this species. H. L. Clark describes them as more or less oval in his key to the species of *Macrophiothrix*, but as Tortonese points out, Müller & Troschel's original description mentions lateral angles, a statement open to several interpretations but suggesting at least something a little more angular than an ellipse. Koehler's plate 83, fig. 13, of the arm of a Philippine specimen shows dorsal arm-plates of which the widest part is midway between proximal and distal edges, whereas all the Red Sea specimens that I have seen have the widest part distinctly distal to the half-way line with a slightly rounded angle as opposed to the very acute angle of *M. longipeda*. This rather fan-shaped form is shown in Koehler's plate 31, fig. 1, of a specimen from the Red Sea, which also resembles the present material in the characters of the disk. That the shape of the dorsal arm-plates varies in different parts of the range is shown by the fact that Lyman's species from Zanzibar, *O. cheneyi*, which is commonly accepted as a synonym of *M. hirsuta*, is described as having oval, microscopically granulated dorsal arm-plates.

The latter feature, that is the presence of more or less thorny granules on the dorsal arm-plates, is not mentioned by Müller & Troschel, but Marktanner-Turneretscher states that they are always somewhat granulated although this is not so marked as in *O. demessa*. In fact he considers the difference in the size and thorniness of these granules to be the only difference separating the two species. Through the courtesy of Dr. Elisabeth Deichmann I have had the opportunity of studying some specimens of *O. demessa* and as a result fully agree with Marktanner-Turneretscher, the only other difference that I can see being that the arms seem to taper more rapidly, in younger specimens at least, of *O. demessa*. The granules on the arms are distinctly more thorny than in the specimens from the Red Sea, where they may be quite unobtrusive in spirit specimens. H. L. Clark in his John Murray Report names two specimens from the Red Sea and the Gulf of Aden *Ophiothrix demessa*, of which the one in the British Museum is indistinguishable from *M. hirsuta*, and I suspect that Koehler's record of *O. demessa* from the Red Sea is also based on a similar specimen. In 1946 H. L. Clark erected a new genus *Amphiophiothrix* to accommodate the species *O. demessa*, but I cannot agree that there is a generic distinction between it and *Macrophiothrix hirsuta*.

The validity of some of the other Indo-Pacific species of *Macrophiothrix* has been questioned by several authorities. Some of them are possibly variants of other species such as *hirsuta* in which the granulation of the radial shields is reduced, for there is a tendency for such a reduction throughout the genus as there is also for the development of granules on the dorsal arm-plates, a character featuring in the descriptions of several species, such as *M. rugosa* H. L. Clark, and noticeable also in some larger specimens of other species. However, without seeing the types and being able to compare them with large series of specimens from different parts of the Indo-Pacific, it is impossible to add anything concrete to the suspicions already voiced.

3. CRINOIDEA

Family Comasteridae

Capillaster multiradiata (Linnaeus)

Asterias multiradiata, Linnaeus, 1758: 663.
Capillaster multiradiata, A. H. Clark, 1909: 364.
†*Capillaster multiradiata*, A. H. Clark, 1931: 173, pls. iii. 5; xi. 30; xiii. 34; xiv. 35, 36; lxxxi. 222, 223, also many text-figs.

Dahab; 1 specimen; arms 90 mm. in length.

This is the first record of this species from the Red Sea, the former known range being from Formosa south to northern Australia and west as far as the Maldive Islands, so its discovery here is most interesting.

There are 36 arms, which is rather more than usual; A. H. Clark gives 12 to 35 as the usual range, but quotes specimens with up to 43 arms.

4. ECHINOIDEA

Family Toxopneustidae

Tripneustes gratilla (Linnaeus)

Echinus gratilla Linnaeus, 1758: 664.
Tripneustes gratilla, Loven, 1887: 77. †Mortensen, 1943, **3** (2): 500, pls. xxxiii. 1–3; xxxiv. 2–6; xxxv. 3–4; xxxvii. 1–2, 4–10; xxxviii. 1–4; lvi. 11.

Abu Zabad, reef at low spring tide; 3 specimens. Sanafir; 1 specimen. Dahab; 6 specimens. Aqaba; 2 specimens.

The two from Aqaba are superficially very different from the others, having relatively few and long primary spines above the ambitus, which are white in colour and contrast sharply with the dark purple of the test, produced mainly by the numerous pedicellariae. The tube feet of these two specimens are black or at least have a black band around them. The other specimens are more drab in colour, several being slightly reddish and their tube feet are grey. The denuded tests are distinctly green aborally.

Family Clypeastridae

Clypeaster (Rhaphidoclypus) fervens Koehler

Clypeaster fervens Koehler, 1922: 45, pls. vi. 1, 2, 6; xv. 1.
†*Clypeaster* (*Rhaphidoclypus*) *fervens*, Mortensen, 1948, **4** (2): 84, pls. xiii. 2, 3; xxii. 1–11; xxvi. 2; lxv. 7–9, 12, 20.

Dahab, shore; 1 dead test.

This specimen is easily distinguished from *Clypeaster humilis* by the relatively large petals and the concave oral side. It is 46 mm. in length but already has well-developed genital pores. According to Dr. Mortensen (who has very kindly confirmed my identification) in his monograph, the genital pores only begin to appear when the length is about 56 mm., that is in the John Murray Expedition material from the Indian Ocean. It seems then that in the Red Sea this species undergoes precocious genital development.

5. HOLOTHUROIDEA

Family Holothuriidae

Holothuria sucosa Erwe

Cucumaria hartmeyeri Helfer, 1912: 332. [non *Holothuria hartmeyeri* Erwe, 1913: 383, pl. vii. 19.]
†*Holothuria sucosa* Erwe, 1919: 186, text-fig. 5. Panning, 1934, **3**: 80, text-fig. 64.
? *Holothuria ocellata*, Tortonese, 1936: 235, text-figs. 5, 6.

Dahab; 1 specimen.

The knobbed buttons have 4 or 5 pairs of holes, sometimes as many as 10 pairs. Unlike *H. arenicola* var. *boutani* Herouard, which also has multilocular, though flat buttons, the tables, which are also larger, have a complete ring of holes around the margin not interrupted by the extended four central holes. Unlike *H. ocellata* Jäger, the great majority of buttons have more than 3 pairs of holes.

Microthele nobilis (Selenka)

Mulleria nobilis Selenka, 1867: 31, pl. xvii. 13–15.
†*Holothuria* (*Microthele*) *nobilis*, Panning, 1929, **1**: 131, text-fig. 15.
Microthele nobilis, Heding, 1940: 320.

Ras Muhammad; 1 specimen.

Although shrunken in preservation this specimen still measures 24 cm. in length. The tables have mostly rather irregular disks. The other dorsal deposits are 'three-dimensional buttons', fenestrated irregularly with about 4 pairs of holes on each face. Ventrally, however, these spicules are much outnumbered by more conventional flat buttons with holes in one plane, there being usually 4 or 5 pairs of holes if not more.

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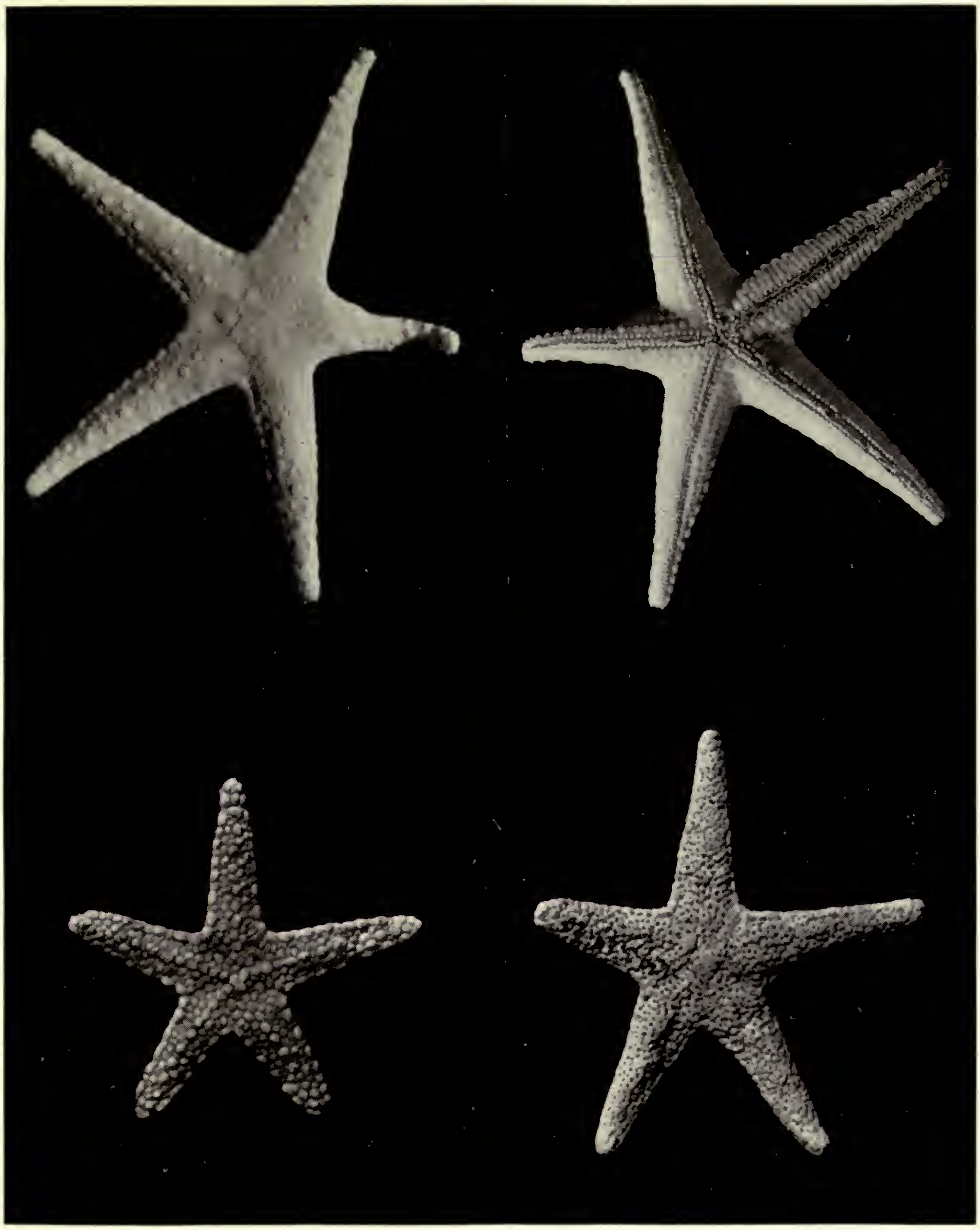
Legends to Plates 31 and 32

PLATE 31

Fromia ghardaqana Mortensen, specimen from Dahab. (*a*) Dorsal side; (*b*) ventral side; (*c*) specimen 40.3.23.35; and (*d*) *Fromia milleporella* Lamarck, specimen 39.3.29.20, for comparison.

PLATE 32

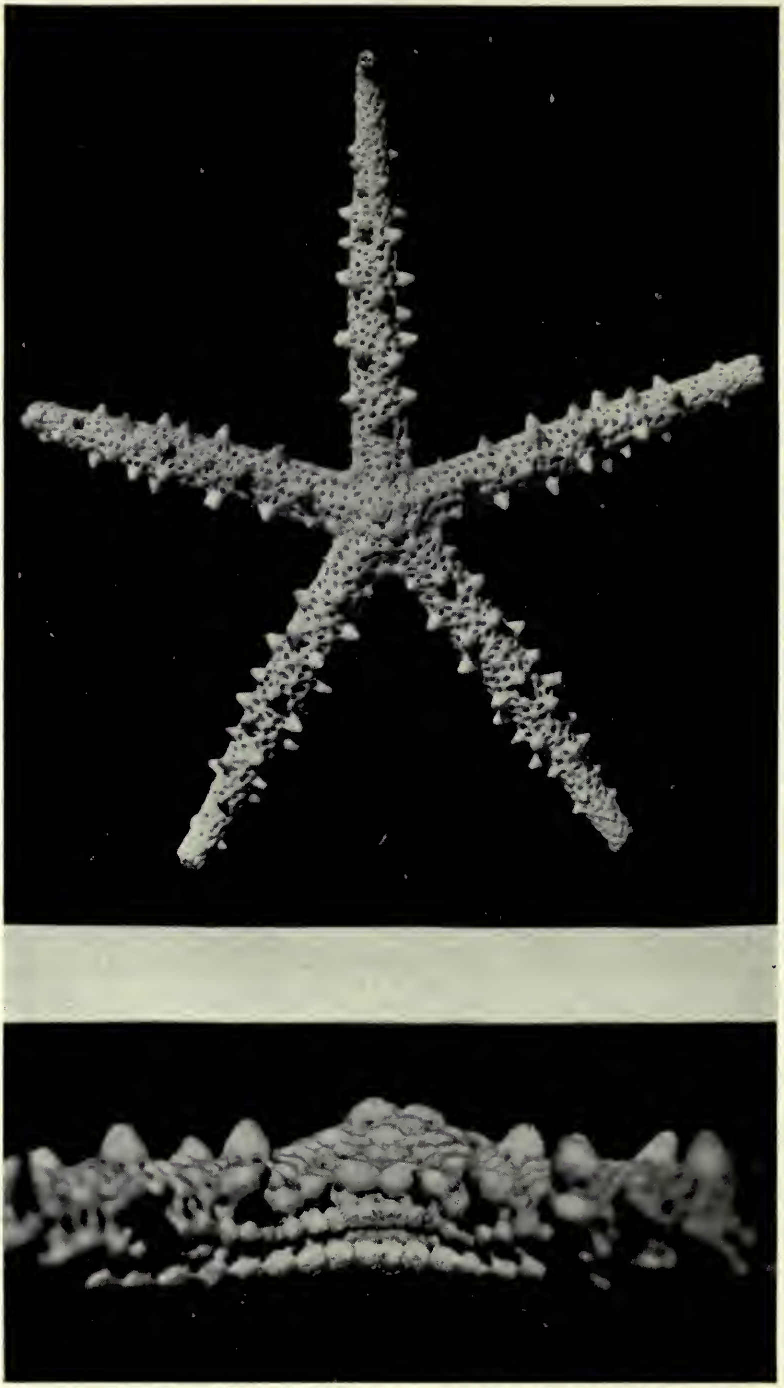
Gomophia egyptiaca Gray. (*a*) Dorsal side of the type and (*b*) an interbrachial angle to show the intermarginal plates.



FROMIA GHARDAQANA MORTENSEN (Figs. *a*-*c*)
FROMIA MILLEPORELLA LAMARCK (Fig. *d*)

a

b



GOMOPHIA EGYPTIACA GRAY

VIII. TUNICATA

By WILLARD G. VAN NAME

AMERICAN MUSEUM OF NATURAL HISTORY

THROUGH the kindness of the authorities of the British Museum (Natural History) the Tunicata collected by the M.Y. *Manihine* in the Gulf of Aqaba in the early months of 1949 were forwarded to me for examination.

As far as I am aware no collection of Tunicata has previously been made there, but the tunicates of the Red Sea, and especially those of the Gulf of Suez, have been the subject of much study and are dealt with in several published articles.

The remarkable work by Savigny (1816), which was many decades in advance of his time, and which laid the foundations of much of our knowledge of the Tunicata, as well as important articles by Hartmeyer, Michaelsen, and others during the present century, were based in large part on specimens from those waters.

It was therefore hardly to be expected that new species would be found in a comparatively small collection, especially since no specimens were obtained except in very shallow water, in no case over about 2 fathoms.

All the specimens appear to be referable to species already described, but nevertheless the collection contains some that are of interest, especially those of the solitary form of *Salpa maxima* var. *tuberculata* described by Metcalf, 1918, from the southern Philippines, who, however, had specimens of the aggregated form only.

Since the Gulfs of Suez and Aqaba are extensions of the Red Sea and consequently of the tropical part of the Indian Ocean, their faunas are Indo-Malayan, in spite of their near approach geographically to the eastern Mediterranean.

This fact is, however, not so evident in the present collection as might be expected, since it happens to contain some species that are practically circumtropical, and found both in the Mediterranean and Indian Ocean. These species are shallow water forms, and it is possible that some of them may owe their very extensive distribution to human agency, by transportation on the bottom of ships.

The Tunicata in this collection appear to belong to the following 13 species, one of them (*Salpa maxima*) being perhaps represented by two varieties:

Class ASCIDIACEA

COMPOUND ASCIDIANS

1. ***Polyclinum saturnium*** Savigny, 1816

Polyclinum saturnium Savigny, 1816: 190, pl. 19, fig. 1; Michaelsen, 1920: 9.

One rather thick colony measuring over 50 mm. in extent.

2. ***Didemnum candidum*** Savigny, 1816

Didemnum candidum Savigny, 1816: 194, pl. 4, fig. 3, pl. 20, fig. 1.

Several small colonies with abundant spicules, whose points are so short and

slightly developed that the spicules are almost spherical. Also one small colony having spicules with larger and better developed rays or points.

There is also one colony, growing on coral, which has very few spicules and a great many faecal pellets in the intestinal tracts of the zooids, perhaps indicating an incipient case of the so-called 'Hypurgon' condition to which this and allied forms are subject, in which the water currents in the cloacal canals become too weak to carry off the waste material, which remains in the cloacal system and in the common test, greatly altering the character and appearance of the colony, but there does not seem to be any reason for assuming that it is of a different species. See Michaelsen, 1919*a*: 11–13.

Didemnum candidum appears to be a species of very wide distribution, being found also in American waters, very abundantly in some places.

It cannot be doubted that far too many species of the genus *Didemnum* have been described. Apparently this is in part due to overlooking the great effects on the general appearance of the colony of its age and past history, particularly in the case of old colonies. Many or most of the species are subject to periods (in many cases seasonal) of regression and extensive degeneration of the zooids, followed by subsequent recovery and regrowth of the colony to its normal functional condition. During such regressive periods, though the zooids degenerate more or less completely, the spicules may endure unchanged through several or perhaps many generations of the zooids. The result is that in old colonies we may find a far greater abundance of spicules than the spicule-forming ability of the zooids present could possibly account for, and likewise often peculiarities in the distribution of the spicules, which one must not mistake for specific characters. Old colonies are apt to acquire a hard calcareous character in which the spicules form a far larger component than the test substance and zooids do.

Simple Ascidians

3. ***Phallusia nigra*** Savigny, 1816

Phallusia nigra Savigny, 1816: 163, pl. 2, fig. 2; pl. 9, fig. 1.
Ascidia atra Lesueur, 1823: 2, pl. 1, fig. 2.
Ascidia nigra, Herdman, 1882: 210.
Phallusia nigra, Hartmeyer, 1916: 408, figs. 5–9.

Eleven specimens, all of small size. This species, widely distributed and common in shallow water in many warm regions of both hemispheres, is easily recognizable from its bluish or blue-black coloration.

If *Phallusia* is accepted as a genus distinct from *Ascidia*, the present species should be placed in it, as in old and large individuals the neural duct has accessory apertures, at least in many specimens. In other respects it is a very typical *Ascidia*.

4. ***Phallusia*** sp., apparently ***Phallusia arabica*** Savigny, 1816

Phallusia arabica, Hartmeyer, 1916: 414, figs. 10–12.

One specimen of 52 mm. body length (or 63 mm. if the obliquely forwardly extending atrial siphon is included). In external features other than unusual forward

position of the atrial siphon (probably only an individual peculiarity), as well as in a majority of the internal characters, it agrees well with the descriptions of Savigny and Hartmeyer cited above.

But this specimen is abnormal and defective in the slight development of the dorsal tubercle, which is practically wanting, although its aperture, which is U-shaped, with the open interval obliquely forward and to the left and with one of the ends bent down, is clearly visible, but very small. Yet I was not able to find any neural duct extending from its aperture, nor any neural gland. Even the ganglion was only doubtfully demonstrated. The neural duct should be long in this species, with accessory lateral openings as well as the terminal one in the dorsal tubercle. The tissues of this specimen were dark coloured and somewhat opaque, but that would not account for the difficulty of finding the above structures if they were present in a normal state of development.

5. ***Ascidia cannelata*** (Oken), 1820

Phallusia sulcata Savigny, 1816: 162, pl. 9, fig. 2. (Name preoccupied.)
Phallusia cannelata Oken, *Isis, 1820*: 796.
Ascidia cannelata, Hartmeyer, 1916: 400, fig. 1.

One specimen, 32 mm. in length, growing on coral.

6. ***Rhodosoma turcicum*** (Savigny), 1816

Phallusia turcica Savigny, 1816: 165, pl. 10, fig. 1.

Seven specimens, all rather small except one 45 mm. long. This, apparently the only species of its genus, is found in many tropical seas, and is readily recognizable by the two apertures being near together in a cleft of the test which can be tightly closed to give them protection. Said to be in most places a rather uncommon species; apparently the Gulf of Aqaba is an exception, as is also the island of Curaçao, West Indies.

7. ***Cnemidocarpa hemprichi*** Hartmeyer, 1916

Cnemidocarpa hemprichi Hartmeyer, 1916*a*: 218, figs. 6, 7.

One specimen of very irregular external form, about 29 mm. long. Found associated with coral in a depth of 2 fathoms.

8. ***Polycarpa mytiligera*** (Savigny), 1816

Cynthia mytiligera Savigny, 1816: 158, pl. 8, fig. 2.
Polycarpa mytiligera, Hartmeyer, 1916*a*: 208, figs. 1, 2.

Two specimens, each of which contained a relatively large symbiotic macruran crustacean in the branchial cavity.

9. ***Herdmania momus*** (Savigny), 1816

Cynthia momus Savigny, 1816: 143, pl. 1, fig. 2; pl. 6, fig. 1.
Cynthia pallida Heller, 1878: 96, pl. 3, figs. 17, 18.

Five specimens, all of rather small size and apparently all representing the typical variety of this widely distributed species of warm regions.

10. *Microcosmus exasperatus* Heller, 1878

Microcosmus exasperatus Heller, 1878: 99, pl. 3, fig. 19.

Three very small specimens. This is also a species of extensive distribution in tropical and warm-temperate waters.

11. *Halocynthia spinosa* Sluiter, 1905

Halocynthia spinosa Sluiter, 1905: 15, pl. 2, figs. 8–8*d*.

Five specimens, the largest about 20 mm. in greatest diameter.

This species, more or less red or pink in colour in life, is easily recognizable from its spiny exterior, the spines about the aperture on the siphons being especially long and conspicuously provided with sharp lateral branches.

12. *Molgula dione* (Savigny), 1816

Cynthia dione Savigny, 1816: 153, pl. 7, fig. 1.

One specimen, about 22 mm. long, found on coral.

Class THALIACEA

Pelagic Tunicata

All the Thaliacea in the collection are of one species, *Salpa maxima* Forskål, 1775, which is found in both the Atlantic and Pacific Oceans, and though reported also from the southern part of the Indian Ocean, has apparently not previously been recorded from the Red Sea. The specimens, with the possible exception of some immature ones as noted below, belong to the following variety of this species:

13. *Salpa maxima* Forskål, 1775, var. *tuberculata* Metcalf, 1918

Metcalf, 1918, *Bull. U.S. Nat. Mus.*, No. 100, **2** (2): 87, fig. 72.

Described by Metcalf (who had examples of the aggregated form only, from the southern Philippines). The 'Manihine' collection has large adult examples of both aggregated and solitary forms, collected with dip nets near the surface, in some cases with the aid of a light.

Five adult specimens of the aggregated form agree well with Metcalf's description and figures, in having the anterior and posterior processes of the body longer than in the typical *S. maxima*, and in having on each side of the external body surface an oval area of the thickened test at the base of the atrial siphon, bearing small acute conical spinous tubercles as described by Metcalf, the area on left side being the larger.

Four adult examples of the hitherto undescribed solitary form of the variety *tuberculata*, the largest about 135 mm. in length, also differ from the solitary form of the typical *S. maxima* in having external spinous areas, though these are small. There are three of these in the case of the solitary form, the most conspicuous one being a narrow transverse strip of thickened test extending across the rear end of the

body just below (ventral to) the base of the atrial siphon, bearing two not very regular rows of conical spinous tubercles similar to those in the aggregated form. The rows are one above the other, and extend slightly farther on the left than on the right side. On the dorsal surface of the body, above the intestinal 'nucleus', there is on each side a thickened area of test bearing a few conical tubercles, but both areas are of small extent, especially the one on the right side.

The variety *tuberculata* appears to be a well-marked one, but the differences from the typical form are superficial and hardly seem to justify considering it a distinct species, especially since we do not yet know the extent to which intermediate forms may occur.

The collection also contains a number (over 50) of young specimens of *S. maxima*, aggregated form, measuring up to about 20 mm. in length exclusive of the anterior and posterior processes. Many of these, when collected, were still adhering together as parts of chains, but due to transportation and handling are now all separated. It is likely that they are all the young of the variety *tuberculata*, but as they fail, probably because too young, to show the varietal characters, they have been labelled simply *Salpa maxima*.

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APPENDIX

Ascidian from Mukalla Bay

Apparently *Ascidia savignyi* Hartmeyer, 1916

A large specimen of the genus *Ascidia* from Mukalla Bay, South Arabia (A. Fraser-Brunner, coll. 17–12–1948) is not included in the above list of specimens as it was not from the Gulf of Aqaba. It is remarkable for its large size (about 160 mm. long by 35 mm. transversely) and greatly elongated form, due chiefly to much lengthening of the anterior half of the body, though the siphons (both of which arise at the anterior end) are short, and the branchial one is much distorted. The internal structure does not show much abnormality, though the branchial sac extends close to the anterior end of the body, and the dorsal tubercle (whose aperture is irregular S-shaped, with the upper end bent down), also the neural gland and ganglion, are close to it and very near to the circle of tentacles. The branchial sac has no intermediate papillae; the internal longitudinal vessels are numerous (over 70 on the left and over 80 on the right side); the intestinal loop (about 37 mm. long) is far back in the body.

It is evidently an unusually old individual; one that has grown in a favourable position in respect to food-supply and protection from predatory fishes and crabs, but where surrounding obstructions compelled it to become unusually elongated.

A similar specimen might be hard to find again, but I do not think it should be assumed to be a new and undescribed species, though such mistakes have too often been made, resulting in burdening literature with supposed species having no real existence. Such a specimen is hard to identify with certainty, but I think it is an unusually large and abnormally shaped example of *Ascidia savignyi* Hartmeyer, 1916. (*Sitzungsber. Gesell. naturf. Freunde Berlin*: **1916:** 404), described from the Sinai coast and Gulf of Suez.

In that article Hartmeyer mentioned (p. 407) the close relationship of *A. savignyi* to *A. depressiuscula* Heller, 1878, described from Ceylon, and common in the Philippines, which is a species that also attains rather large size. I am quite ready to agree with this opinion, and think he was also probably correct in believing it related to the European species *A. virginea* Mueller, but I do not consider it also related to *A. paratropa* (Huntsman) of the American Pacific coast, as Hartmeyer believed. That species has intermediate papillae on the branchial sac, and belongs to a different section of the genus.

IX. FISHES

By N. B. MARSHALL, M.A.

THE collection comprises 113 species, of which 1 is new, while 4 sub-species have been proposed. There are 11 new records for the Red Sea (these being indicated by an asterisk preceding the name of the species).

Collections were made from 28 December 1949 to 16 February 1950, coming from various localities along the Sinai shores of the gulf and from an area around the entrance. These include Aqaba, Faraun Island, Graa, Mualla, Wasit, Hobeik, Dahab, Um Nageila, and Abu Zabad within the gulf and Tiran Island, Sanafir Island, Sherm-el-Moiya, Sherm Sheikh, and Ras Muhammad Bay around the entrance. For the positions of these localities reference should be made to the chart in the introduction to this series of reports.

The fishes were captured by a variety of methods: cast-net, fish-trap, hand-lines, trolling gear, and dip-net. In addition many were taken by bringing up pieces of coral and breaking them open to obtain the enclosed fishes, while a number were obtained from pools along the reef at low water. The method of capture is indicated under each species, giving certain information on the habits of the fish. For example, those taken by cast-net occurred singly or in shoals in shallow water close to the shore, while those taken by trolling spoon or live bait were nearly always caught along the seaward edge of reefs, where they appear to station themselves to prey on smaller fishes living in association with coral. Clearly those found within pieces of coral must live in close association with it, darting back to shelter on being disturbed by the diver. Perhaps no more striking way of appreciating the direct or indirect dependence of so many tropical fishes on coral can be obtained than through the many ways necessary to obtain them as specimens.

SELACHII

CARCHARINIDAE

Negaprion acutidens (Rüppell)

1 specimen of length 660 mm.[1] taken close inshore in Ras Muhammad Bay.

Carcharinus melanopterus (Quoy & Gaimard)

1 specimen of 535 mm. caught by hand-line at Sanafir Island.

Carcharinus albimarginatus (Rüppell)

1 specimen of 870 mm. caught by hand-line at Sherm Sheikh.

[1] Except for the Selachii and the eels, lengths throughout this paper refer to the standard length.

Rhinobatidae

Rhinobatus halavi (Forskål)

Six specimens were taken in very shallow water in Ras Muhammad Bay. One of these is a female of length 507 mm., while the rest are males ranging from 355 to 520 mm.

Dasyatidae

Dasyatis uarnak (Forskål)

One specimen taken by hand-line at a depth of 10 fathoms at the anchorage in Sanafir Island. The disk is about 1,000 mm. in length and 1,250 mm. wide. The tail, from which the whip-like end is missing, has a length of about 1,250 mm.

Taeniura lymma (Forskål)

Three specimens were obtained by cast-net close inshore at Sanafir Island (length 570 mm.), and at Mualla (length 445 mm.) and Um Nageila (length 564 mm.) within the Gulf of Aqaba.

ISOSPONDYLI

Clupeidae

Sub-family dussumieriinae

Spratelloides delicatulus (Bennett)

Individuals of this species were taken with a dip-net and Aldis lamp at night. Faraun Island: 10 specimens from 21 to 50 mm. Sanafir Island: 15 specimens from 40 to 45 mm.

Spratelloides gracilis (Schlegel)

Like the preceding species, this was caught by dip-net at night in the light of an Aldis lamp. Hundreds of specimens were taken at the anchorage at Sanafir Island, ranging in length from 9 to 39 mm.

I have compared some of these specimens with material in the museum collections from Japan and Formosa (the type locality being along the south-east coast of Nagasaki). There are differences in the number of pectoral and anal fins as shown in the table below:

	Pectoral (left)			*Anal*			
No. of rays	13	14	15	11	12	13	14
Red Sea specimens	3	7		5	7	1	
Japanese specimens		3	6		2	6	2

On the basis of the above counts it seems not unlikely that the Red Sea populations should be separated as a distinct sub-species; but lacking data from areas between the end points of the range of this species it is considered premature to subdivide it.

INIOMI

Synodontidae

Synodus variegatus (Lacépède)

One specimen of 130 mm. taken in a pool at Dahab.

APODES

Muraenidae

Echidna nebulosa (Ahl)

Two specimens of 444 and 460 mm. taken on the reef at Abu Zabad at low tide.

Echidna polyzona (Richardson)

One specimen from Abu Zabad of 195 mm. and two from Sanafir Island of 115 and 165 mm. The latter were found in a piece of madreporarian coral.

Gymnothorax meleagris (Shaw)

Seven specimens were obtained from the following localities: Dahab (108 mm.), Abu Zabad (145 and 160 mm.), Sanafir Island (111, 165, and 180 mm.), Sherm Sheikh (100 mm.). Except those from Abu Zabad, which were obtained on the reef at low tide, all were found in pieces of madreporarian coral brought up for examination.

Gymnothorax flavimarginata (Rüppell)

One specimen of 295 mm. taken on the reef at Abu Zabad at low tide and one of 880 mm. from Ras Muhammad Bay.

Gymnothorax geometrica (Rüppell)

Two examples of 130 and 143 mm. taken from pieces of coral at Sherm-el-Moiya and Sanafir Island respectively.

The body colour of these specimens was fawn with the pattern of dark pigment

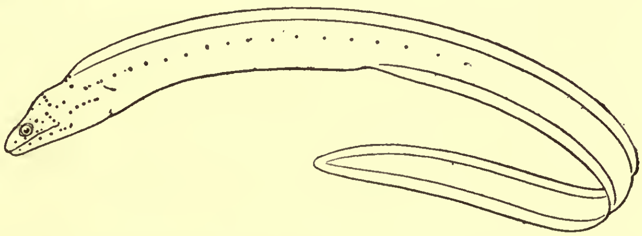

Fig. 1. An immature specimen of *Gymnothorax geometrica* (Rüppell) from Sherm-el-Moiya in the northern Red Sea, showing the pattern of dark spots on the head and body.

spots on the head looking rather like a series of lateral line pores (see Fig. 1). These spots extend down the mid flanks as a single line, extending just beyond the anus.

This spot pattern was also found in specimens from the collections labelled *Gymnothorax thyrsoidea* (Richardson): 2 from Rodriguez, 1 from the Seychelles, 1 from Muscat. These specimens differed from those listed above in having a dotted and speckled body coloration, but as all these Indian Ocean examples were much larger it is likely to be a difference due to age. Rüppell's (1828) figure shows a mottled body coloration.

There can be no doubt that *G. geometrica* (Rüppell) and *G. thyrsoidea* (Richardson) are very closely related, the only apparent difference between them being the absence of the spot pattern in the latter. However, as this pattern seems quite constant in *G. geometrica* and as the pattern only appears to be found in individuals from the western Indian Ocean, the two species have been kept separate. Further work may perhaps show that what is now called *geometrica* is a western Indian race of a widely spread species. (This species will, of course, need to be called *G. geometrica*—this name having priority over *G. thyrsoidea*.)

If *Gymnothorax geometrica* is a distinct species its distribution must include the western Indian Ocean as well as the Red Sea.

Uropterygius polyspilus (Regan)

One specimen from Sanafir Island of length 201 mm. taken in a piece of coral.

Schultz (1943) has suggested that this species is perhaps the young of *Uropterygius tigrinus* (Lesson). Examination of the above specimen, together with the type specimen from Tahiti (length 183 mm.) and two specimens from Samoa (331 mm.) and Zanzibar (715 mm.), shows that *polyspilus* is distinct from *tigrinus* (a specimen of 860 mm. was examined) in the following characters:

1. The number and size of the outer maxillary teeth: 20–28 in *polyspilus*, which are much smaller than the inner series of maxillary teeth; 12–13 in *tigrinus*, which are nearly the size of the inner series. (Bleeker, *Atlas Ichthyologique*, **4**, 1864: 113, counts 16 outer maxillary teeth for *tigrinus*. The figure on plate 165 shows them almost equal in size to the inner series.)
2. The proportions between trunk and tail: about equal in length in *polyspilus*, but in *tigrinus* the trunk is about 1·7–1·8 times longer than the tail.
3. The proportions between the eye and the snout: in *polyspilus* the length of the snout is from 1·7 to 1·8 times the diameter of the eye, whereas in *tigrinus* the snout is about 2–3 times the eye diameter.

SYNENTOGNATHI

Belonidae

Strongylura crocodilus (Lesueur)

One specimen from Sanafir Island of 465 mm.

Hemirhamphidae

Hemirhamphus far (Forskål)

One specimen from Sanafir Island of 300 mm.

Exocoetidae

Danichthys rondeletii (Cuvier & Valenciennes)

Four specimens taken off Alexandria, which were attracted on board by a light. Lengths 152, 164, 173, and 180 mm. Bruun (1935) has suggested that *D. rondeletii* in the Mediterranean might prove to be a dwarf race distinct from the Atlantic form. Examination of the above specimens, 2 others from the Mediterranean (B.M. Reg. No. 73.4.21.2–3) and 1 from the Atlantic (B.M. Reg. No. 71.12.28.8) has yielded data which when added to those listed by Bruun and Breder (1938) provides evidence to support this suggestion.

The essential differences between the two forms are in the number of pectoral rays and transverse scales (and very probably in the sizes attained, the Atlantic form being known up to 234 mm. in standard length and the Mediterranean up to 187·5 mm.). These differences are shown below:

Atlantic specimens	*Pectoral rays*	*Mediterranean specimens*
1	16	3
11	17	9
5	18	1
1	19	

Atlantic specimens	*Transverse scales (between origin of dorsal fin and lateral line)*	*Mediterranean specimens*
2	6½	9
13	7½	1

It would appear from these data that the Mediterranean form can nearly always be separated from the Atlantic by the number of transverse scales. If more evidence, in particular more from the Mediterranean, shows this is so, then this species must be split into Atlantic and Mediterranean sub-species.

MICROCYPRINI

Cyprinodontidae

Aphanius dispar (Rüppell)

One female of 32 mm. taken on the reef at Abu Zabad at low tide.

SOLENICHTHYES

Fistulariidae

Fistularia villosa Klunzinger

Four specimens from Dahab from 600 to 790 mm. Another specimen of 105 mm. taken with a dip-net at Sanafir Island is probably of this species. In determining this species I have used the revision by Duncker & Mohr (1925) and other specimens in the collections.

The colour was noted as follows: 'a line of misty-blue spots on either side of the mid-dorsal line extending from the pectoral fins to the dorsal. Below this line (about ½") a continuous misty-blue line extended from about 1" in front of the pelvics to 1" behind the end of the dorsal, thereafter continuing as a line of spots.'

Syngnathidae

Micrognathus brevirostris (Rüppell)

Three specimens found in a piece of coral at Sanafir Island. Two males of 37·0 and 47·5 mm. and one female of 44·0 mm.

BERYCOMORPHI

Holocentridae

Holocentrum spiniferum (Forskål)

Three specimens taken by hand-line at Sanafir Island (278 and 300 mm.) and Sherm Sheikh (295 mm.) at depths of about 10 fathoms.

Holocentrum sammara (Forskål)

One specimen from Sanafir Island (length 134 mm.).

Holocentrum diadema Lacépède

Two specimens of about 45 mm. from a piece of coral at Tiran Island.

Holocentrum lacteoguttatum (Cuvier & Valenciennes)

Two specimens of 45 and 54 mm. Taken at low tide on the reef at Abu Zabad.

PERCOMORPHI

(Sub-order PERCOIDEA)

Serranidae

(Sub-family serraninae)

Plectropoma maculatum (Bloch)

One specimen of 440 mm. caught by hand-line at Sanafir Island.

Variola louti (Forskål)

Two specimens of 385 and 287 mm. taken by hand-line at Dahab (10 fms.). This species could also be caught by trolling a spoon or live bait.

Cephalopholis miniatus (Forskål)

Two specimens of 280 and 287 mm. taken by hand-line at Dahab.

Cephalopholis hemistictus (Rüppell)

Three specimens, two from Dahab of 131 and 140 mm. and one from Hobeik of 131 mm.

Intensive field and laboratory work may show the two above species to be synonymous. Klunzinger (1884) states that the only distinguishing feature is in the coloration, which he says is constant in *hemistictus*. There is, however, considerable variability. The usual body colour in *hemistictus* is brownish or dark olive-green with small bright blue, ocellated spots on the head and lower half of the flanks (mainly found on the thoracic and abdominal regions), while there is a broad yellow edging to the pectoral fin. The three specimens from the Gulf of Aqaba differ from this in the general body colour, this being a bright red as in *C. miniatus*. (Two other specimens from the Gulf of Aden and one from the Makran coast also must have had this coloration.) What is also interesting on all these specimens are the pale pelvic fins with a narrow outer black edging which is also found in *C. miniatus* (in typical *C. hemistictus* they have a general, dusky pigmentation). Again, the area of the body covered with the blue spots in *hemistictus* varies considerably from being confined to part of the abdominal region to practically extending over the lower half of the flanks, with a few spots appearing dorsally above the lateral line. Finally in five specimens labelled *Epinephelus miniatus* from Mombasa there are two specimens of 226 and 242 mm. with the normal colour pattern, while the remaining three from 151 to 171 mm. (which agree in all characters but colour with the above two) are completely plain coloured. There is no trace of spots and only a faint dark edging to the caudal and anal fins can be seen. Presumably these were coloured a bright red in life.

Although it is quite possible that these species merge with one another, they have been separated particularly on account of the difference in distribution, *Cephalopholis hemistictus* being confined to the Red Sea and western Indian Ocean, whereas *C. miniatus* occurs throughout the Indo-West-Pacific area. There is here an interesting parallel with the eels *Gymnothorax geometrica* and *G. thyrsoidea* which were discussed earlier in this report.

Epinephelus summana (Forskål)

One specimen of 440 mm. from Sanafir Island taken by hand-line.

Epinephelus fuscoguttatus (Forskål)

Six specimens. Four from Sanafir Island from 325 to 890 mm. caught by hand-line in depths from 5 to 20 fathoms. Two from Abu Zabad of 51 and 123 mm. taken on the reef at low tide.

Epinephelus fasciatus (Forskål)

Seventeen specimens taken at the following localities: Dahab, 5 from 34 to 175 mm.;

Hobeik, 3 from 190 to 220 mm.; Abu Zabad, 7 from 46 to 76 mm. collected from pools on the reef at low tide; Sanafir Island, 1 of 43 mm.; Sherm Sheikh, 1 of 205 mm.

(Sub-family THERAPONINAE)

Therapon jarbua (Forskål)

Thirteen specimens captured by cast-net at Sherm Sheikh (12 from 79 to 116 mm.) and at Abu Zabad (1 of 167 mm.).

Investigations of these specimens together with others in the collections has shown that there are certain regional differences in the number of dorsal spines and the relation between the depth of body and the standard length as shown in the following table:

Area	*No. of dorsal spines* *11*	*12*	$\frac{depth}{length} \times 100$	*No. of specimens*	*Size range (mm.)*
Red Sea	13	—	29·5–32·0	13	79–167
Arabian coast	5	—	32·0–35·0	5	80–276
Persian Gulf	4	2	33·0–38·0	6	58–63·5
Coasts of India and Ceylon	12	—	32·1–38·6	12	26–113
East African area	2	6	30·7–35·0	8	54–204
East Indies	1	10	32·2–37·0	11	23–151
Philippine Islands	1	2	36·1–37·2	3	90–117
Fiji and Samoa	—	2	35·5–35·7	2	141–154
China	—	3	31·5–32·9	3	34·5–96·5
Australia	—	2	30·9–33·6	2	67–210

Although these data are rather limited, it is clear that in the Red Sea *Therapon jarbua* has 11 spines in the dorsal fin (previously found by Klunzinger, 1884) and also tends to be slenderer in form than representatives from the Indo-Pacific areas. Furthermore, the proportion of the Indian Ocean specimens having 11 as against 12 spines is 23:8, whereas in the Pacific Ocean this is 2:19. Of specimens from the Pacific, those from the Philippines, Fiji, and Samoa have the deepest body form.

It is thus quite evident that the populations of *Therapon jarbua* are by no means uniform in character. Whether, for example, the Red Sea population can be considered to be part of a sub-species found mainly in the north-west Indian Ocean (having 11 dorsal spines), which intergrades over a wide area with a typical Pacific sub-species (having 12 dorsal spines), can hardly be decided on the present data. It is, however, a problem worth much further investigation.

During this work it became necessary to decide whether *Therapon servus* (Bloch) is distinct from *T. jarbua* (Forskål). Weber & de Beaufort (1931) have synonymized them but refer to the work of Jordan & Thompson (1912), who decided that they were good species, particularly separated by the longitudinal scale counts just above the lateral line. The present work confirms Jordan & Thompson's conclusions and shows that in general *Therapon servus* has relatively smaller scales than *T. jarbua*, as shown in the following table.

Scale count	*Therapon jarbua*	*No. specimens seen*	*Therapon servus*	*No. specimens seen*
1. Longitudinal series above the lateral line	77–89	57	92–105	12
2. Transverse scales	(12) $\frac{14\text{–}17}{25\text{–}30}$	55	$\frac{17\text{–}21}{30\text{–}35}$	12
3. Rows of scales on preoperculum	8–11	57	11–13	12

SERRANIDAE

Sub-family GRAMMISTINAE

Grammistes sexlineatus (Thunberg)

Three specimens from 70 to 82 mm. taken at low tide on the reef at Abu Zabad.

Sub-family PSEUDOCHROMIDINAE

Pseudochromis olivaceus Rüppell

All the examples of this species were taken from pieces of coral brought up by a diver. Within the Gulf of Aqaba collections were made at Graa (2 specimens of 26 and 45 mm.), Mualla (4 specimens of 23–47 mm.), and at Dahab (4 specimens from 37 to 59 mm.). There are also 34 from 26 to 70 mm. taken at Sanafir Island and 8 from 29 to 54 mm. taken at Sherm-el-Moiya.

Comparison has been made between the Gulf of Aqaba individuals and some of those taken outside the entrance in the Red Sea. There does appear to be some difference in the number of pectoral rays, which are tabulated below:

Pectoral rays	*17*	*18*	*19*
Gulf of Aqaba	3	6	1
Sanafir Island	—	10	2

This species is confined to the Red Sea.

PLESIOPIDAE

Plesiops nigricans (Rüppell)

Twenty-three specimens from 33 to 63·5 mm. collected at Abu Zabad at low tide.

CHEILODIPTERIDAE

Apogon endekataenia Bleeker

Nine specimens from Abu Zabad from 53 to 61 mm., collected on the reef at low tide.

These specimens agree in structure with two specimens in the collections (labelled as types) which were obtained from Bleeker (B.M. Reg. No. 1880.4.21.59–60). The latter have nearly lost all trace of colour but still retain the remains of the spot on

the base of the caudal fin which Weber & de Beaufort (1929) list as one of the characters separating *A. endekataenia* from *A. novemfasciatus* C.V. Comparison of these specimens with those of *novemfasciatus* shows the two to be very distinct in tooth character. In the latter the teeth are relatively large, there being 4 rows in the upper and lower jaws while in *endekataenia* there are from 6 to 9 somewhat irregular rows of smaller teeth. Comparison of specimens of equal size shows that the teeth of *novemfasciatus* are about twice the size of those of *endekataenia.*

Examination of the museum collections has not revealed any examples of *A. novemfasciatus* from the Red Sea or Indian Ocean. Klunzinger (1884) notes that his specimens (which he names *A. fasciatus* White) show clearly the black spot on the base of the tail. Smith (1949), however, records it as quite common north of Zululand.

Cheilodipterus quinquelineatus Cuvier & Valenciennes

Three specimens from 31 to 38 mm. taken at Abu Zabad.

Latilidae

****Malacanthus hoedtii*** Bleeker

One specimen from Sherm Sheikh of 207 mm.

Carangidae

Caranx fulvoguttatus (Forskål)

One specimen from Sanafir Island of 170 mm.

Caranx sexfasciatus Quoy & Gaimard

Two specimens of 544 and 800 mm. caught by trolling a spinner at Sanafir Island.

Lutianidae

Lutianus bohar (Forskål)

Two specimens caught by hand-line at Sanafir Island (length 310 mm.; depth 20 fms.) and at Sherm Sheikh (length 357 mm.; depth 6 fms.).

Lutianus argentimaculatus (Forskål)

One specimen of 345 mm. caught by hand-line at a depth of 20 fms. at Sanafir Island.

Lutianus fulviflamma (Forskål)

Three specimens caught by hand-line (two from Sanafir Island of 222 and 232 mm. taken at 20 and 8 fms. respectively; one from Sherm Sheikh of 209 mm. from 6 fms.)

Lutianus kasmira (Forskål)

Six specimens taken on hand-lines Four from Sherm Sheikh at 147–182 mm. and two from Hobeik at 209 and 211 mm.

Aphareus rutilans Cuvier & Valenciennes

One specimen of 765 mm. obtained from the cold store at Aqaba.

This is one of the finest food fishes taken in the Gulf of Aqaba and is known to the Arab fishermen as Faris. It is caught by hand-line mainly at depths of about 100 metres.

Mullidae

Parupeneus macronema (Lacépède)

Five specimens. Three obtained by cast-net (two at Dahab of 145 and 149 mm. and one at Sanafir Island of 96 mm.). The other two of 83 and 84 mm. were caught in a fish-trap at Aqaba at a depth of 10 fathoms.

Lethrinidae

Lethrinus nebulosus (Forskål)

Two specimens of 320 and 450 mm. caught by hand-line at Sanafir Island (5 fms.) and Dahab (15 fms.) respectively.

Lethrinus mahsena (Forskål)

Four specimens taken at Dahab (two of 290 and 310 mm. at 12 fms.) and Sanafir Island (two of 225 and 257 mm. at 5 fms.).

Lethrinus microdon Cuvier & Valenciennes

Five specimens, of which three are from Aqaba (86–97 mm.) taken in a fish-trap at a depth of 10 fathoms. The other two were caught by hand-line at Dahab (length 317 mm.; depth of water 7 fms.) and Sanafir Island (length 360 mm.; depth 5 fms.).

Lethrinus mahsenoides ([Ehrenberg] Cuvier & Valenciennes)

Twelve specimens. Seven from Aqaba taken in a fish-trap set at 10 fathoms. Three from Dahab of 176, 183, and 184 mm. caught by hand-line at a depth of 10 fathoms. One from Hobeik of 200 mm. from a depth of 10 fathoms, and one from Sherm Sheikh of 162 mm. from 6 fathoms.

Weber & de Beaufort (1936) have remarked that *L. mahsenoides* from the Red Sea is hardly separable from *L. ornatus* C.V. (= *L. insulindicus* Bleeker). I have compared the above specimens and one of Klunzinger's from the Red Sea (labelled *mahsenoides*) with those labelled '*mahsenoides*' and *insulindicus* taken outside the Red Sea. I could find no significant differences.

Gymnocranius griseus (Schlegel)

One specimen from Hobeik of 300 mm. taken by hand-line at a depth of 10 fathoms.

The above specimen has been compared with two from Mauritius (B.M. Reg. Nos. 1932.8.8.22 and 1934.2.22.25) and one from the Loyalty Islands (77.7.24.2), but there appear to be no differences. Specimens from nearer the type locality (SW. coasts of

Japan) differ from the Red Sea and Indian Ocean examples in being deeper bodied (these were from Hong Kong, B.M. Reg. No. 1939.1.17.38 and the Inland Sea of Japan, B.M. Reg. No. 1907.12.23.230–1). The depth in these is about half the standard length as against $\frac{5}{11}$ to $\frac{5}{13}$ in the Red Sea and Mauritius specimens. There is, also, a difference in coloration, for the Red Sea and Indian Ocean specimens have the wavy blue lines across the head, a coloration which never seems to be present in Pacific Ocean fishes of this species. Fowler (1933) has even made this difference the basis for two sub-genera.

SPARIDAE

Sparus bifasciatus (Forskål)

Two specimens from Sanafir Island (92·5 mm.) and from Um Nageila (154·0 mm.). On comparing these specimens with others in the museum collections it became quite evident that there are two definite colour varieties. The first, which is found in the Red Sea, the Gulf of Aden, along the South Arabian coast (Muscat), and in the Persian Gulf, has plain hyaline or yellow dorsal and caudal fins. The other from the Makran coast of Baluchistan, the north-western Indian coast, and the East African area (specimens from Kosi Bay, Zululand, and Rodriguez) always has a black edging to the dorsal fin and sometimes a black edging in the fork of the caudal. Reference to the literature on this species confirms this difference in pigmentation and the geographical range of each type.

In body proportions and height and lengths of the fins there are no significant differences between these two forms. In fin ray and scale counts there are also no differences, except that there appears to be a definite tendency for the East African examples to have 13 rays in the soft dorsal rather than 12. Smith (1938) also gives 13 as the number of dorsal rays in a specimen from Natal. Counting the latter, five out of six East African examples have 13 rays, whereas from the rest of the area of distribution only one out of eighteen had this number; the rest had 12.

It is not the intention to do more at this stage than draw attention to this differentiation within the populations of this bream. More data on the Baluchistan and north-west India populations would be of interest, for at present it appears that, although they have the same colour pattern as the East African, they tend to have 12 dorsal rays rather than 13 (5 out of 6 examined). Yet one specimen from this area did have 13 rays. It is of interest to note that in all instances this number was associated with a black-edged dorsal fin.

Sparus haffara Forskål

Two specimens of 165 and 172 mm. taken by cast-net at Sanafir Island.

Argyrops spinifer (Forskål)

One specimen of 357 mm. caught by hand-line at Dahab at a depth of 10 fathoms.

Diplodus noct ([Ehrenberg] Cuvier & Valenciennes)

Ten specimens taken by cast-net at the following localities: Dahab (2 of 66·0 and 136 mm.), Abu Zabad (2 of 140 and 146 mm.), Sanafir Island (6 from 76·0 to 88·0 mm.).

The distribution of this species is given as the Red Sea, the Arabian and Indian coasts, and Madagascar (Fowler, 1933).

Close comparison of the above material with specimens labelled *Diplodus noct* from Karachi (1) and from the Persian Gulf (11) (from Bushire) has shown them to be quite different. The latter are actually *Diplodus sargus* (Linnaeus). They are, in fact, the same fish as another series labelled *Diplodus capensis* from Muscat, Arabia, the latter being a synonym of *D. sargus*.

The characters showing the differences between *Diplodus noct* from the Red Sea and *D. sargus* from the Persian Gulf and north-west Indian coast are listed below. The measurements and counts on *D. noct* were made on the 10 specimens listed above and 1 other of length 212 mm. from Klunzinger's collection, while those on *D. sargus* were obtained from the 11 specimens from the Persian Gulf (ranging in length from 62·0 to 130·0 mm.), 1 from Karachi (of 109 mm.), and 4 from Muscat (from 140 to 213 mm.).

Diplodus noct (Ehrenberg) (C.V.). The greatest depth of the body is from 39·0 to 42·1 per cent. of the standard length. Dorsal XII. 12–14 (5 specimens with 13 rays, 4 with 14, 1 with 12). Anal III. 12–13 (5 with 12 rays, 6 with 13). Scale count above and below lateral line 6–7/15–16. Number of gill rakers on 1st arch 6–7+1+12–13.

Diplodus sargus (L.). The greatest depth of the body is from 45 to 50 per cent. of the standard length. Dorsal XII. 13–15 (2 specimens with 13 rays, 10 with 14, and 2 with 15). Anal 12–14 (2 specimens with 12 rays, 9 with 13, and 4 with 14). Scale count above and below the lateral line 8–9/15–18. Number of gill rakers on 1st arch 6+1+9–10.

Reference to the literature suggests, in conjunction with the above data, that *D. noct* is confined to the Red Sea. Day (1875) records this species from the Red Sea and Sind (NW. India). His synopsis (p. 133) fits very well with the characters listed above for *D. noct* and his figure (pl. 32, fig. 5) is almost certainly drawn from a specimen of *noct*. Unfortunately he does not state the locality of this specimen, but does mention that this fish is common at Suez. His specimens from NW. India may well have been *D. sargus*.

Sargus kotschyi Steindachner from the Arabian Gulf, Madagascar, which is synonymized with *Diplodus noct* by Fowler (1933), is probably a synonym of *D. sargus*. In particular the number of scale rows (8) above the lateral line is a good indication.

In the course of this work specimens of *Diplodus sargus* from the Mediterranean were compared with those from Muscat and the Persian Gulf and good agreement found between them. The only difference found was in the number of scale rows above the lateral line, which in the Mediterranean examples was 7 to 8 compared to 8 to 9 in those from the Arabian area. It is hoped at a later date to investigate the degree of differentiation within this species.

Crenidens crenidens (Forskål)

Twelve specimens taken by cast-net at the following localities: Dahab (8 specimens from 68·5 to 95 mm.), Sanafir Island (4 specimens from 107 to 120 mm.).

Comparison of these specimens with others from Aden (6 collected by Mr. A. Fraser-Brunner) and Karachi (13) has shown that this species can be divided into two sub-species.

The first is typified by specimens from the Red Sea. The diagnosis which follows is based on the 12 specimens listed above, 1 of 123 mm. from the Red Sea (Rüppell's collection), Ismailia (Suez Canal) (1 of 152 mm.), Korbrat, Suez (1 of 109 mm.), and the Gulf of Suez (1 of 95 mm.). The latter three specimens were collected by the Cambridge Expedition to the Suez Canal, 1924.

Crenidens crenidens crenidens (Forskål)

Depth of body 33·3–38·9 per cent., depth of caudal peduncle 9·9–10·9 per cent., height of third dorsal ray 9·6–11·1 per cent., and length of pelvic fin 18·1–21·2 per cent. of the standard length. Rows of scales above lateral line (from origin of dorsal) 5–6 (7 specimens with 5 rows and 9 with 6 rows). Rows of scales below lateral line 11–12 (2 specimens with 11 rows and 14 with 12 rows). Red Sea.

Synonymy. Presumably all references to *Crenidens crenidens* (Forskål) or *Crenidens forskâlii* C.V. from Red Sea localities must come under this sub-species.

Sparus crenidens Forskål, 1775, *Descript. Animal.*: 15 (type locality Red Sea: Djidda or Suez).
Crenidens crenidens, Norman, 1927, *Trans. zool. Soc. Lond.* **22**: 380.
Crenidens forskâlii, Cuvier & Valenciennes, 1830, *Hist. Nat. Poiss.* **6**: 378, pl. 162 quater (type locality: Red Sea). Gunther, 1859, (partim) *Cat. Fish. Brit. Mus.* **1**: 424. Klunzinger, 1870, *Verh. zool. bot. Ges. Wien*, **20**: 748. Day, 1875, (partim) *Fishes of India*, **1**: 133.
Crenidens forskaelii, Day 1889 (partim) *Fauna British India* **2**: 35.

The second sub-species is typified by a series of 13 specimens from Karachi ranging in length from 52·5 to 164 mm. The following diagnosis is based on these individuals.

Crenidens crenidens indicus Day

Depth of body 43·3–49·1 per cent., depth of caudal peduncle 11·4–12·8 per cent., height of third dorsal ray 11·6–13·9 per cent., and length of pelvic fin 20·7–25·2 per cent. of standard length. Rows of scales above the lateral line 6–7 (3 specimens with 6 rows and 10 with 7 rows). Rows of scales below the lateral line 12–15 (3 specimens with 12 rows, 2 with 13 rows, 7 with 14 rows, and 1 with 15 rows). Karachi.

Synonymy.

Crenidens indicus, Day, 1873. The sea-fishes of India and Burma from Report on the sea fish and fisheries, p. clxxxvi, No. 184. Day, 1875, *Fishes of India*, pt. 1: 132, pl. 32, fig. 4. Day, 1889, *Fauna of British India*, **2**: 34, fig. 13. Steindachner, 1907, *Denkschr. Akad. Wiss. Wien.* **71** (1): 136. Blegvad, 1944, *Danish Sci. Inv. Iran*, **3**: 143, fig. 80, pl. viii, fig. 3.
Crenidens macracanthus, Gunther, 1874. *Ann. Mag. nat. Hist.* (4) **14**: 368 (type locality: Madras).

Of particular interest are the six specimens from Aden mentioned above which range from 127 to 167 mm. in length. These have the following proportions and

counts: Depth of body, 39·7–44·0 per cent., depth of caudal peduncle 11·1–12·0 per cent., height of third dorsal ray 9·0–11·0 per cent., and length of pelvic fin 20·3–21·5 per cent. of the standard length. Scale rows 6–12 (13 in one specimen).

It will be seen that these individuals resemble *Crenidens crenidens crenidens* in the relative height of the third dorsal ray and the scale counts, but in depth of body, caudal peduncle, and length of pelvic fin they are more like *C. c. indicus*. It was the examination of these intermediate specimens which partly suggested the differentiation of *C. crenidens* into Red Sea and Arabian Sea sub-species.

As the diagnosis shows, the latter sub-species *indicus* is quite distinct along the north-west coast of India and seemingly in the Iranian Gulf, to judge from pl. viii, fig. 3, in Blegvad's report (1944, loc. cit.). More specimens from the south Arabian coasts are clearly required.

There is also little comprehensive data from the East African area. Two specimens from Mombasa and Port Natal of 118 and 186 mm. respectively closely correspond with *C. c. indicus* in body proportions, but like *C. c. crenidens* have 6 and 12 rows of scales above and below the lateral line. On the other hand, the accurate figures of Smith (1938, fig. 21, and 1949, pl. 44, fig. 732), together with the descriptions, give much more the impression of *C. c. crenidens*. It is thus evident that many more specimens from this area must be studied before the *C. crenidens* complex can be more fully appreciated.

Pempheridae

Pempheris sp. (probably *P. moluca* C.V.)

Twenty-five juvenile specimens from 17 to 23 mm. caught by dip-net close inshore at Faraun Island.

Chaetodontidae

Chaetodon fasciatus Forskål

One specimen of 88 mm. caught by cast-net around coral at Sanafir Island.

This species is confined to the Red Sea.

Anisochaetodon auriga (Forskål)

Three specimens of 43, 48, and 51 mm. taken by cast-net at Sanafir Island.

None of these examples have the elongated fifth or sixth dorsal ray. The two smaller specimens have a round black spot towards the 'apex' of the dorsal fin.

Platax orbicularis (Forskål)

Nine specimens from 64 to 84 mm. taken by cast-net at Sanafir Island.

The above individuals together with two more from the Red Sea have been compared with examples from the Indian and Pacific Oceans (Ceylon (2), Seychelles (1), Mombasa (1), Singapore (1), Borneo (2), Philippines (2), Manado (3), and the coast of Savaii (1)).

There appear to be no differences except in the number of pectoral rays (counted in the left fin).

Pectoral rays	*16*	*17*	*18*	*19*
Red Sea . .	3	7	1	—
Indo-Pacific . .	1	4	7	1

Pomacentridae

Amphiprion bicinctus Rüppell

One specimen of 52 mm. taken by dip-net among coral at Dahab.

Abudefduf biocellatus (Quoy & Gaimard)

Eighteen specimens from 34 to 62 mm. taken on the reef at Abu Zabad at low tide. Three of the above have the typical *biocellatus* colour pattern: the rest have only the posterior ocellus at the base of the last few dorsal spines.

Abudefduf sordidus (Forskål)

Three specimens of 87, 119, and 123 mm. caught by cast-net around rocks.

Chromis coeruleus (Cuvier & Valenciennes)

Forty-eight specimens, all taken from pieces of coral obtained by a diver at the following localities: Sanafir Island, 36 from 22 to 44 mm.; Sherm Sheikh, 9 from 27 to 34 mm.; Dahab, 3 from 18 to 36 mm.

Dascyllus aruanus (Linnaeus)

Forty-four specimens obtained from pieces of coral at the following localities: Sanafir Island, 38 from 17 to 50 mm.; Graa, 3 from 28 to 32 mm.; Dahab, 3 from 40 to 46 mm.

Dascyllus marginatus (Rüppell)

Five specimens from 20·5 to 36·0 mm. obtained from a piece of coral at Dahab (depth 25 fms.).

Comparison of these specimens and others from the Red Sea with those from localities in the Indian and Pacific Oceans has shown that a separate sub-species may occur in the Red Sea. A description of the diagnostic features follows below, based on the five specimens listed above, 1 from the northern Red Sea, taken off the Gulf of Aqaba (length 38·0 mm.), B.M. Reg. No. 1938.1.24.3; 2 from the Red Sea (of 39 and 42 mm.), B.M. Reg. No. 1935.9.1.5; 3 from the Kamaran Islands (from 32 to 41 mm.), B.M. Reg. No. 1937.4.26.8.10; and 18 from Massaua (from 24 to 44 mm.), B.M. Reg. No. 71.4.13.40.

Dascyllus marginatus marginatus (Rüppell)

(FIG. 2*a*)

Length of longest dorsal ray (usually the fifth) from 21·9 to 28·7 per cent. of the standard length (mean 23·8 per cent.; length of longest anal ray (usually the fourth) from 22·5 to 28·0 per cent. of the standard length (mean 25·3 per cent.). Rays in left pectoral fin (17) 18–19 (20) (2 specimens with 17 rays, 5 with 18 rays, 21 with

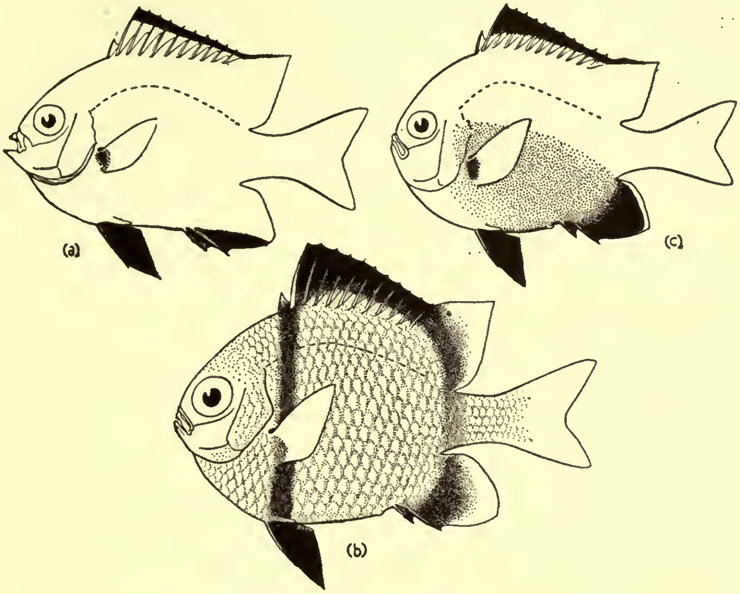

FIG. 2*a*. *Dascyllus marginatus marginatus*. Locality: Dahab, Gulf of Aqaba.

FIG. 2*b*. *Dascyllus marginatus reticulatus*. Locality: Philippine Islands.

FIG. 2*c*. A specimen of *D. marginatus* from Aden—intermediate in certain respects between the two above sub-species.

19 rays, and 1 with 20 rays). General body colour pallid to brownish (in spirits) with the anterior half to two-thirds of the trunk usually tending to be darker in colour than the rest of the body. Upper third to a half of spinous dorsal black; this edging continuing along the soft dorsal as a rather thinner band as far as the tips of the longest dorsal rays. Anal fin with membranes between the spinous and first 5 or 6 soft rays coloured black, contrasting sharply with the posterior half of the fin where the fin membranes are translucent.

Distribution. Red Sea.

Synonymy.

Pomacentrus marginatus Rüppell, 1828. *Atlas Reise nordl. Afrika. Fische des Rothen Meers.*: 38. pl. 8, fig. 2 (type locality: Massaua, Red Sea).

Dascyllus marginatus Cuvier & Valenciennes, 1830. *Hist. Nat. Poiss.* **5:** 439, pl. 133. Günther,

1862, *Cat. Fish. Brit. Mus.* **4:** 14. Klunzinger, 1871, *Verh. zool. bot. Ges. Wien* **21:** 520. Kossman & Rauber, 1877. *Zool. Ergebn. K. Acad. Wiss. Berlin,* **1:** 23. Borsieri, 1904, *Ann. Mus. Civ. Genova* (3) **1** (41): 214. Bamber, 1915, *J. linn. Soc. Lond.* **31:** 481.

The other material studied was as follows:

Specimens from the Gulf of Aden collected by Mr. A. Fraser-Brunner, 3 specimens from Alayu, British Somaliland (from 30·5 to 34·0 mm.); 5 specimens from Berbera, British Somaliland (from 27·5 to 35·5 mm.); 1 specimen from Perim (of 35 mm.); 1 from Aden (of 33·5 mm.) and 1 from Burum near Mukalla, Indian Ocean; 2 from Zanzibar, B.M. Reg. No. 64.11.15.100 and 65.3.18.35 (of 48·0 and 52·5 mm.); Pacific Ocean[1]; 3 from Rotuma, B.M. Reg. No. 97.8.23.141–143 (from 26·0 to 63·5 mm.)[1]; 1 from Borneo, B.M. Reg. No. 58.4.21.363 (of 42 mm.)[1]; 1 from Ponape, B.M. Reg. No. 76.5.19.7 (of 31·0 mm.), and 8 from Duquamete, Or Negros, Philippine Islands, B.M. Reg. No. 1933.3.11.440–7 (from 25·0 to 58·0 mm.). The type specimen of *Dascyllus nigripinnis* Regan was also examined (B.M. Reg. No. 1908.3.23.98).

Dascyllus marginatus reticulatus (Richardson)

(Fig. 2*b*)

Length of longest dorsal ray from 19·8 to 23·2 per cent. of the standard length (mean 21·1 per cent.). Length of longest anal ray from 19·1 to 24·5 per cent. of the standard length (mean 21·3 per cent.). Rays in left pectoral fin (19) 20–21 (1 specimen with 19 rays, 7 with 20 rays, and 8 with 21 rays).

General body colour brown to dark brown (in spirits), the darker edging of the scales often showing up as a reticulated pattern over the body. Spinous dorsal fin dark brown, this pigmentation not extending to the longest rays of the soft dorsal. Anal fin uniformly dark brown, although sometimes the distal half of the fin may appear lighter.

Distribution. Indo-West Pacific area (excluding the Red Sea).

Synonymy. This is not complete, but lists all the names which have been proposed for the Indo-Pacific individuals of this sub-species.

Heliases reticulatus, Richardson, 1845 (1846), *Rep. Brit. Ass. Adv. Sci. Ichth. China & Japan*: 254 (type locality: China Seas).

Tetradrachmum reticulatum, Bleeker, (1872), *Ned. Tijdschr. Dierk.* **2:** 145.

Dascyllus xanthosoma, Bleeker, 1851, *Natuurk. Tijdschr. Ned.-Ind.* **2:** 247.

Dascyllus marginatus, Playfair & Günther, 1866, *Fishes of Zanzibar*, **277:** 81.

Pomacentrus unifasciatus, Kner, 1868, *S.B. Akad. Wiss. Wien*, **58** (1): 31, 348, pl. 8, fig. 24.

Dascyllus nigripinnis, Regan, 1907, *Trans. linn. Soc. Lond. Zool.* (2) **12:** 228, pl. 24, fig. 5. Type locality: Maldives.

Dascyllus trimaculatus (non Rüppell), Fowler, 1918, *Copeia*, **58:** 64.

Finally the specimens from the Gulf of Aden were found to have the following characteristics:

Length of longest dorsal ray 21·4–24·6 per cent. of standard length (mean 22·7 per cent.). Length of longest anal ray 20·6–25·9 per cent. of standard length (mean 22·3 per cent.). Rays in left pectoral 17–19 (1 with 17, 2 with 18, and 8 with 19 rays). Colour in spirits dark purple-brown to brown with the caudal peduncle and the region

[1] These are labelled *Dascyllus xanthosoma.*

over the dorsal half of the body and below the dorsal fin lighter in colour. Distal half to two-thirds of spinous dorsal black, this continuing as a thin edging to the soft dorsal as far as the tips of the largest rays. Anal, except for a lighter posterior edging, brownish black (see fig. 2*c*).

It will be seen that these specimens are in certain respects intermediate between the two sub-species described above. In colour they are much like *D. m. reticulatus*, although that of the dorsal fin is more like *D. m. marginatus*.

In number of pectoral rays they are clearly closest to *marginatus*, but are perhaps intermediate in the height of the longest dorsal and anal rays. The existence of intermediate forms in the Gulf of Aden suggests that this is an area where the two sub-species meet and interbreed. Much more material is required, however, from both the southern end of the Red Sea and the Gulf of Aden to establish the interrelations of the sub-species.

Labridae

Labroides dimidiatus (Cuvier & Valenciennes)

One specimen of 27 mm. caught by hand-net among coral at Mualla.

Thalassoma güntheri (Bleeker)

Four specimens caught by hand-line at the following localities: Sanafir Island, 2 of 105 and 107 mm.; Tiran Island, 1 of 102 mm.; and Sherm Sheikh, 1 of 154 mm.

Thalassoma lunare (Linnaeus)

Two specimens of 115 and 151 mm. caught by hand-line at Ras Muhammad Bay.

Stethojulis axillaris (Quoy & Gaimard)

Two specimens of 53 and 66 mm. taken at Abu Zabad at low tide on the reef.

Stethojulis albovittata (Bonnaterre)

One specimen of 79 mm. taken at Abu Zabad at low tide on the reef.

**Halichoeres margaritaceus* (Cuvier & Valenciennes)

Three specimens of 37, 43, and 51 mm. taken at low tide on the reef at Abu Zabad.

Cheilinus mentalis Rüppell

Eight specimens from 55 to 87 mm. taken at Aqaba in a fish trap set at 10 fathoms. De Beaufort (1940) has correctly synonymized *Cheilinus orientalis* Günther with this species. There are no differences between the above specimens and the type specimen (B.M. Reg. No. 1864.5.15.8).

Pseudocheilinus hexataenia (Bleeker)

Four specimens all taken from pieces of coral. Three from Sanafir Island of 19, 23, and 29 mm. and one from Sherm Sheikh of 22·5 mm.

Scaridae

Leptoscarus vaigiensis (Quoy & Gaimard)

One specimen of 100 mm. collected on the reef at Abu Zabad at low tide.

Sub-order ACANTHUROIDEA

Acanthurus nigrofuscus (Forskål)

Three specimens collected at Mualla by cast-net (2 of 57 and 86 mm.) and at Abu Zabad at low tide (1 of 55 mm.).

Sub-order TEUTHIDOIDEA

Teuthis rivulatus (Forskål)

Five specimens taken by cast-net at Um Nageila (3 of 217, 220, and 235 mm.) and Sanafir Island (2 of 130 and 172 mm.).

Sub-order SCOMBROIDEA

Thynnus (Neothunnus) albacora (Lowe)

One specimen of 1,070 mm. obtained from Arab fishermen who were catching this fish and the one following at a depth of about 100 metres, a few miles south of Aqaba.

Euthynnus (Katsuwonus) pelamis (Linnaeus)

One specimen of 670 mm. obtained a few miles south of Aqaba from local fishermen.

Scomberomorus commerson (Lacépède)

One specimen of 860 mm. from Sanafir Island, caught by trolling spoon-bait.

Sub-order GOBIOIDEA

Eleotridae

****Eviota gymnocephalus*** M. Weber

Fourteen specimens, all obtained from pieces of coral brought up by a diver (5 from Sanafir Island from 10·0 to 16·0 mm.; 4 from Sherm Sheikh from 8·0 to 14·0 mm.; 1 from Sherm-el-Moiya of 15·0 mm.; 2 from Graa of 9·5 and 10·0 mm.; and 2 from Dahab of 13·0 and 15·5 mm.).

****Eviota distigma*** Jordan and Seale

Four specimens obtained from pieces of coral at Sherm Sheikh (3 from 13·0 to 17·0 mm.) and Graa (1 of 14·0 mm.).

Heterelotris vulgare (Klunzinger)

Eighteen specimens collected from pieces of coral at the following localities: Sanafir Island (10 from 18·0 to 26·0 mm.), Tiran Island (1 of 17·0 mm.), Mualla (3 from 18·0 to 23·0 mm.), Dahab (4 from 19·0 to 25·0 mm.).

This species has only been recorded from the Red Sea.

Klunzinger (1870) remarks that the body of this fish appears to be without scales. I was also unable to find any trace of scales.

GOBIIDAE

Bathygobius fuscus (Rüppell)

Three specimens collected at Dahab (1 of 34·0 mm.), Mualla (1 of 50·0 mm.), and Abu Zabad (1 of 47·0 mm.). All were taken close inshore where they were found under stones and rocks.

Acentrogobius ornatus (Rüppell)

Two specimens of 38·0 and 58·0 mm. taken under stones at Abu Zabad at low tide.

Gobiodon quinquestrigatus (Cuvier & Valenciennes)

Forty-four specimens, all obtained from pieces of coral at the following localities: Dahab (7 from 16·5 to 38·0 mm.), Sanafir Island (24 from 12·5 to 38·0 mm.), Tiran Island (10 from 16·0 to 37·0 mm.), and Sherm Sheikh (3 from 22·0 to 30·0 mm.).

****Gobiodon erythrospilus*** Bleeker

Three specimens obtained from coral at Dahab (2 of 34·0 and 37·0 mm.) and Tiran Island (1 of 32·0 mm.).

Gobiodon citrinus (Rüppell)

Six specimens obtained from pieces of coral at Sanafir Island (4 from 27·5 to 32·0 mm.) and Sherm Sheikh (2 of 26·0 mm.).

Paragobiodon echinocephalus (Rüppell)

Three specimens from 20·0 to 23·0 mm. taken from a piece of coral at Sanafir Island.

Sub-order BLENNIOIDEA

BLENNIIDAE

Enchelyurus kraussii (Klunzinger)

One specimen of 30 mm. taken from a piece of coral at Graa. This species has only been recorded from the Red Sea.

Cirripectus variolosus (Cuvier & Valenciennes)

One specimen of 31·0 mm. collected on the reef at Abu Zabad.

Istiblennius edentulus (Bloch & Schneider)

Twenty-five specimens collected under stones and rocks at Abu Zabad (15 from 46·0 to 84·0 mm.) and Dahab (10 from 25·0 to 57·0 mm.).

Istiblennius fasciatus (Bloch)

Two specimens from Abu Zabad (1 of 47·0 mm.) and Sanafir Island (1 of 48·0 mm.).

CONGROGADIDAE

Haliophis guttatus (Forskål)

Four specimens obtained from pieces of coral at Sanafir Island (3 of 50·0, 67·0, and 81·0 mm.) and Sherm Sheikh (1 of 60·0 mm.).

This species appears to be restricted to the Red Sea.

CLINIDAE

*****Helcogramma trigloides*** (Bleeker)

One specimen of 27·0 mm. found in a piece of coral at Mualla.

Sub-order MUGILOIDEA

SPHYRAENIDAE

Sphyraena jello Cuvier & Valenciennes

One specimen of 530 mm. taken by trolling spoon-bait at Sanafir Island.

Sphyraena picuda Bloch. Schneider

One specimen of 760 mm. taken by spoon-bait at Sanafir Island.

MUGILIDAE

Oedalechilus labiosus (Cuvier & Valenciennes)

Eight specimens taken by cast-net at Mualla (2 of 101 and 104 mm.) and Sherm Sheikh (6 from 96 to 127 mm.).

Liza seheli (Forskål)

One specimen of 300 mm. taken by cast-net at Dahab.

Liza crenilabis (Forskål)

One specimen of 69·5 mm. from Dahab and eight specimens from 101 to 164 mm. from Sanafir Island taken by cast-net.

ATHERINIDAE

Hypoatherina gobio (Klunzinger)

Twenty-nine specimens caught by dip-net and a light at night-time at the following

localities: Dahab (7 from 26·0 to 82·0 mm.), Sanafir Island (13 from 46·0 to 92·0 mm.), and Sherm Sheikh (9 from 20·0 to 74·0 mm.).

This species is apparently confined to the Red Sea.

Sub-order SCLEROPAREI

Scorpaenidae

***Scorpaenopsis albobrunneus** (Günther)

Twenty-two specimens, all obtained from pieces of coral brought up by a diver at the following localities: Dahab (8 from 19·0 to 44·0 mm.), Tiran Island (2 of 35·0 and 40·0 mm.), Sanafir Island (7 from 21·0 to 48·0 mm.), Sherm Sheikh (5 from 19·0 to 35·0 mm.).

Pterois volitans Linnaeus

Three specimens taken at Dahab (1 of 155 mm.), Hobeik (1 of 190·0 mm.), and Abu Zabad (1 of 51·0 mm.).

Order ***DISCOCEPHALI***

Echeneididae

Echeneis neucrates Linnaeus

One specimen of 617 mm. caught by hand-line at Sherm Sheikh.

Order ***PLECTOGNATHI***

Balistidae

Odonus niger (Rüppell)

Six specimens caught by hand-line at Sherm Sheikh (4 from 143·0 to 186·0 mm.) and Hobeik (2 of 240·0 and 285·0 mm.).

Balistapus undulatus (Mungo Park)

Two specimens. One of 184 mm. caught by hand-line at Hobeik and one of 35 mm. obtained from a piece of coral.

Rhinecanthus assasi (Forskål)

Four specimens taken at Abu Zabad (2 of 205 and 210 mm.) and Sanafir Island (2 of 170 and 190 mm.).

This species seems to be restricted to the Red Sea, the Gulf of Aden, and the Indian Ocean coast of Arabia.

ALUTERIDAE

Oxymonacanthus halli sp. nov.

(FIG. 3)

Two specimens, the holotype of 38·0 mm. and one paratype of 39·5 mm. taken from a piece of coral at Sanafir Island in the northern Red Sea.

(In the description which follows, measurements and counts of the holotype precede those of the paratype which are placed in brackets.)

Body proportions (relative to a standard length of 100): Greatest depth 35·5 (36·1); length of head 34·8 (35·4); predorsal length (from tip of snout to origin of dorsal fin) 55·5 (55·7); preanal length 61·8 (62·0); depth of caudal peduncle 14·4 (13·3); length of pectoral fin 9·9 (9·5); height of first dorsal spine 23·0 (24·0).

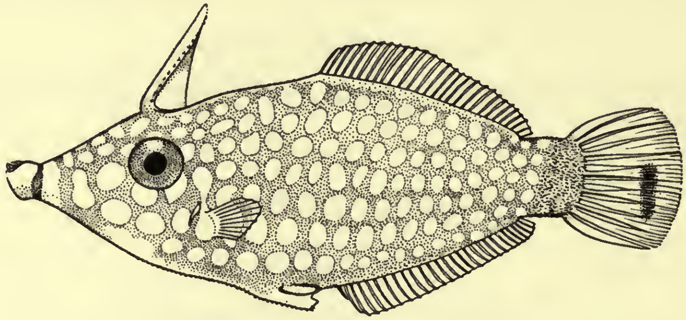

FIG. 3. *Oxymonacanthus halli* sp. nov.

Head proportions (relative to a head length of 100): Length of snout 64·0 (64·3); horizontal diameter of eye 26·4 (25·0).

Fin rays: Dorsal II, 28 (II, 27); anal 27 (25); left pectoral 10 (10); caudal 12.

Body covered with very numerous spinules, which become larger (about twice the length of those immediately behind the eye) and fewer on the caudal peduncle, particularly over the lateral, median regions. These spinules extend out to about three-quarters the length of each caudal ray and are not found on the tip of the snout in front of the brown pigment band which encircles it. First dorsal spine studded anteriorly and laterally with blunt spines, while posteriorly there are two rows of 9 or 10 rather larger blunt spines, the lower of which, at least, project backwards and downwards. Second dorsal spine very small. Immediately posterior to the first dorsal spine there is a fairly deep, wide groove in the back, of much the same length as this spine.[1] Pelvic spine supporting a small ventral flap. Dorsal, anal, and pectoral rays unbranched. Caudal rays branched except for the upper and lower outermost rays which are stouter at the base than the inner rays. Jaws meeting dorsally at the tip of the snout.

General colour blue with longitudinal rows of roughly circular deep yellow spots.

[1] Presumably the long dorsal spine folds into this groove, but I have been unable to unlock the trigger mechanism by pressure on the small second spine.

Between the origin of the dorsal and anal fins nine rows of these spots can be counted. Tip of snout yellow in front of the brown pigment ring which encircles it. Membrane of dorsal fin yellow, pelvic flap orange with a black edging. Caudal with a black vertical bar of pigment. Iris golden with six symmetrically arranged slate blue sectors.

This species differs from *Oxymonacanthus longirostris* (Bloch & Schneider), the only other species of this genus, in the following:

	O. halli	*O. longirostris*[1]
Dorsal rays . . .	27 and 28	31–32
Anal rays . . .	25 and 27	29–30
Pectoral rays . .	10	11–12

In addition there are certain differences in the colour pattern.

1. In *Oxymonacanthus halli* there are no longitudinal yellow stripes in front of the eye as are usually found in *O. longirostris*.
2. There are 9 longitudinal rows of yellow spots (counting across the body between the origins of the dorsal and anal fins) in *O. halli*, whereas in *longirostris* there are usually 7 (occasionally 6 or 8). The number of spots in each row is also greater in the new species. There are 18 or 19 (counting along the row behind the eye), whereas in *longirostris* there are 12–16.
3. In *O. longirostris* there is usually a small area of the abdomen just above the pelvic flap which is differentiated from the rest of the body by being brown in colour and dotted with small white spots. This is absent in the two specimens of *O. halli*.

I have much pleasure in naming this species after Major H. W. Hall, M.C., the owner of M.Y. *Manihine*.

OSTRACIONTIDAE

Ostracion tuberculatus Linnaeus

Two specimens of 270 and 300 mm. taken by cast-net at Sanafir Island.

LAGOCEPHALIDAE

Lagocephalus sceleratus (Forster)

Four specimens from 260 to 280 mm. taken by hand-line at a depth of 10 fathoms at Sanafir Island.

TETRAODONTIDAE

Amblyrhynchotes diadematus (Rüppell)

One specimen of 146 mm. taken by cast-net at Mualla. This species is confined to the Red Sea.

[1] Counts and measurements based on specimens from Samoa (1) (standard length 79·0 mm.), Amboyna (1 of 70·0 mm.), Ponape, Caroline Islands (2 of 43 and 65 mm.), New Britain (1 of 57·0 mm.), and one (no locality given) from Bleeker's collection (67 mm.).

Arothron hispidus (Linnaeus)

Two specimens of 285 and 340 mm. taken by cast-net at Sanafir Island.

These two specimens and another from the Gulf of Suez all have much more numerous and smaller white spots on the body than in examples taken outside the Red Sea.

CANTHIGASTERIDAE

****Canthigaster cinctus*** (Solander)

One specimen of 65 mm. taken by a fish-trap at Aqaba from a depth of 10 fathoms.

DISCUSSION

Among the 113 species considered in this report are a number which appear to be confined to the Red Sea. They may be subdivided as follows:

A. Almost certainly endemic

Pseudochromis olivaceus Rüppell
Crenidens crenidens crenidens (Forskål)
Diplodus noct ((Ehrenberg) Cuvier & Valenciennes)
Chaetodon fasciatus Forskål
Dascyllus marginatus marginatus (Rüppell)
Haliophis guttatus (Forskål)
Hypoatherina gobio (Klunzinger)
Amblyrhynchotes diadematus (Rüppell)

B. Possibly endemic

Heterelectris vulgare Klunzinger
Enchelyurus kraussii Klunzinger
Oxymonacanthus halli Marshall

(The first two species are small and inconspicuous)

C. Species with Red Sea forms distinguishable from those of the Indian Ocean

Spratelloides gracilis (Schlegel)
Therapon jarbua (Forskål)
Platax orbicularis (Forskål)
Arothron hispidus (Linnaeus)

The number of species collected by this expedition probably represents about one-fifth of the total fish fauna of the Red Sea (Klunzinger, 1870 and 1871, lists about 490 species). If it is a representative sample, then about 10 per cent. of the species (and sub-species) known from this area are endemic. Moreover, to judge from the work on this collection, this percentage may well prove to be considerably higher, when more material becomes available for study.

Before discussing how these endemic elements may have originated it will be necessary to outline briefly the geological history of the Red Sea area. Although

the evidence is rather incomplete it seems that the formation of the main physical features were completed during the Pliocene and that during this time the Red Sea became connected with the Gulf of Aden and the Indian Ocean. Fox (1926) suggests that the invasion of Indian Ocean species into the Red Sea occurred some time after the Middle Pliocene. (Earlier an ancestral Red Sea appears to have come into being as the result of the faulting of Eocene strata followed by the filling of the resulting depression with water from the north. Later on the Red Sea appears to have lost its connexion with the northern Tethys Sea, for during Miocene times it shrank in area giving rise to great deposits of rock salt.) Continuing from middle Pliocene times there seems no doubt that there was again a connexion between the Mediterranean (Tethys Sea) and the Red Sea (the latter now containing a mixed Mediterranean and Indian Ocean fauna), but when the Gulf of Suez became cut off from the Mediterranean is not very certain.

This would seem to be the generally accepted geological history of the Red Sea, but Sewell (1948) has considered the implications of Zeuner's (1945) work on the Pleistocene period. Zeuner suggests that during the last Glacial period the sea-level fell as the result of ice formation, his figure for the Mediterranean being −100 metres, while a low level of −200 metres has been suggested for the penultimate glaciation.

Sewell (1948) concludes that this lowering of sea-level might well have left the shallow sill at the southern end of the Red Sea uncovered, which '. . . must have resulted in the almost complete disappearance of the Red Sea as it exists today and its reduction to two small inland lakes which were in all probability hypersaline. Under such changes as these it is difficult to suppose that anything of the marine fauna can possibly have survived, and the original fauna of the Tethys Sea that was derived from the Indo-Pacific region must have disappeared.' Following from this the sea-level once again rose at the end of the Glacial period, resulting in a second and final influx of species from the Indian Ocean into the Red Sea.

Concerning the origin of forms peculiar to the Red Sea there are certainly two possibilities:

1. That they have evolved from species entering the Red Sea.
2. That they may be the only survivors of species which originally lived in the Indian Ocean. It might be suggested, for example, that the Indian Ocean representatives of these species have been eliminated during geological history whereas conditions in the Red Sea favoured their survival.

A third possibility of whether the endemic forms are relics from the ancestral Red Sea seems so unlikely that it will not be considered beyond pointing out that the presence of great rock-salt deposits, probably of Miocene age, implies that this early sea must have been subject to extensive evaporation. As already mentioned, Sewell (1948) concluded that this would be likely to happen and that it most probably resulted in a mass extinction of the marine fauna.

Beginning with the second suggestion, it seems somewhat improbable that this fairly high number of endemic forms should have all possessed the potentialities of surviving in the Red Sea while the Indian Ocean ancestral stock perished. Following

the formation of the 'modern' Red Sea the main hydrological features would gradually have evolved, that is, higher summer temperatures and greater salinities, which now distinguish it from the Indian Ocean. Such changes would have tended to bring about correlated changes in the fish fauna (among them extinction) rather than the preservation of species. To put it another way, it seems unlikely that these forms should have all been pre-adapted to conditions in the Red Sea. While it is not possible to state the latter with certainty, it is of interest that the Red Sea supports fewer species of fishes than the Indian Ocean. Sewell (1948) has similar findings for the free-swimming planktonic Copepoda and suggests that many species which are widely distributed in the Indo-Pacific are unable to survive the changes in salinity and temperature on being carried into the Red Sea.

Turning to the first suggestion, if a number of the ancestral Indian Ocean immigrants have evolved into species and sub-species peculiar to the Red Sea, there should be some evidence for this today. It would be reasonable to expect to find at least some of these endemic Red Sea forms pairing off with the present-day Indian Ocean representatives. Regan (1906–1908) and Meek & Hildebrand (1923), when considering the marine fishes of Panama, have remarked on the many close parallels between the faunas of the opposite sides of the isthmus. It is generally considered that the formation of the Isthmus of Panama during late Pliocene times separated many species into Atlantic and Pacific populations which have diverged in isolation.

In the Red Sea there are certain endemic species which are paired with others from the Indian Ocean. From this collection there are the following pairs:

Red Sea	*Indian Ocean*
Diplodus noct (C.V.)	*Diplodus sargus* (L.) (also occurs in the Med.)
Chaetodon fasciatus Forskål	*Chaetodon lunula* Lacépède
Haliophis guttatus Forskål	*Haliophis malayanus* M. Weber
Oxymonacanthus halli Marshall	*Oxymonacanthus longirostris* (Bloch & Schneider)

While the members of these pairs may well have arisen by the separation of an original species into Red Sea and Indian Ocean populations, they are not sufficiently closely related to draw any certain conclusions as to their past history. Instead, it will be better to concentrate on infra-specific categories. Here there are the proposed sub-species of *Dascyllus marginatus* and the examples listed earlier of differences between Red Sea and Indian Ocean populations of certain species. Judging from the impressions gained in working out this collection and from numerous instances in the literature[1] where Red Sea examples of a species can be distinguished from others from the Indian Ocean, there can be little doubt that when good series of specimens from both areas are available, more species will be found to have Red Sea 'forms'.

The evolution of these endemic elements implies that after entering the Red Sea they became isolated to some degree. Leaving aside problems concerning the Suez Canal, entry via the Gulf of Aden is through the narrow Strait of Bab-el Mandeb, inside which is a shallow sill, where the greatest depth is only about 100 metres. Climatic conditions and the basin-like character of the Red Sea are the predominating

[1] Particular reference may be made to Fraser-Brunner (1950), who remarks that '... among the Chaetodonts at least I find that few or none of the known Red Sea forms are identical with those outside'.

factors controlling the temperature and salinity of the waters, and as already mentioned, the latter features were evolved after the formation of the 'modern' Red Sea. Today very soon after entering the Red Sea the salinity rises by about 2‰ and in summer the surface temperature increases by about 3–5° C. In winter there appears to be little difference between the surface temperatures of the Red Sea and the Gulf of Aden (data from Sverdrup, Johnson, & Fleming, 1942).

Perhaps this quite abrupt change in one or both physical factors may be a barrier to the exchange of Red Sea and Gulf of Aden fishes and has been so long enough for new forms to have arisen. Perhaps the habits of the fishes themselves may be another factor, species which are closely dependent on coral life and less migratory being more prone to differentiation than the more active pelagic species. (While there is the possibility of the larvae of the former types being carried out of the Red Sea (or into it), younger stages are usually more 'exacting' than adults in the physical conditions necessary for their existence; thus such an event may prove disastrous.) Again owing to the changes in temperature and salinity which have occurred since the formation of the Red Sea, certain species may have become reproductively isolated from their Indian Ocean ancestors, through the evolution of differing breeding seasons. In conclusion, however, it should be added that these are no more than suggestions to be tested in the light of further knowledge.

If more data were available on the fish fauna it would be interesting to compare and contrast the Red Sea–Indian Ocean relationships with those found across the Straits of Panama. Concerning the latter area, Gilbert & Starks (1904) in discussing the parallels between the two faunas concluded that:

> 'The ichthyological evidence is overwhelmingly in favour of the existence of a former open communication between the two oceans, which must have closed at a period sufficiently remote from the present to have permitted the specific differentiation of a very large majority of the forms involved. That this differentiation progressed at widely varying rates in different instances becomes at once apparent. A small minority of the species remain wholly unchanged, so far as we have been able to determine that point. A large number have become distinguished from their representatives of the opposite coast by minute (but not "trivial") differences which are wholly constant. From such "representative forms" we pass by imperceptible gradation to species much more widely separated whose immediate relation in the past we cannot confidently affirm.'

Later work by Meek & Hildebrand (1923) did not change these conceptions, except that it was found that fewer species could properly be regarded as common to both coasts and more species were discovered with representative Atlantic and Pacific forms.

It is not proposed on the present limited data to draw conclusions regarding rates of evolution in the Red Sea fauna. Direct comparison with the Panama findings is not, of course, possible for two main reasons: firstly that there is a connexion between the Red Sea and the Indian Ocean (which may make for genetic interchange between the two faunas), and secondly, that there are often greater differences in temperature (but not in salinity) between Red Sea and Indian Ocean waters than exist across the Straits of Panama (this aspect will be discussed later). Whether the degree of endemism of the Red Sea fauna could have been attained since the last Glacial

period (if Zeuner's (1945) figures of drop in sea-levels and Sewell's (1948) conclusions from these are considered), is a question which will best be considered when the large collection of fishes recently obtained from Sudanese waters has been studied.

Finally the fact that the Red Sea is for part of the year warmer and always more saline than Indian Ocean waters must be considered as a 'conditioning factor' in the evolution of Red Sea forms. Before this can be done a list of the differences between closely related forms will be given.

Spratelloides gracilis. The Red Sea populations tend to have fewer pectoral and anal rays than those from the Japanese area.

Therapon jarbua. The Red Sea form has fewer dorsal spines and a slimmer body form.

Diplodus noct. This differs from *D. sargus* from the Indian Ocean in the slimmer body form, the tendency for the dorsal and anal fins to have fewer rays, the smaller number of scale rows above and below the lateral line, and the fewer gill-rakers on the first arch.

Crenidens crenidens. The Red Sea sub-species differs in the slimmer body form, the fewer scale rows above and below the lateral line, and the lesser relative height and length of the soft dorsal and pelvic fins respectively.

Platax orbicularis. Red Sea examples tend to have fewer pectoral rays than those from the Indo-Pacific.

Dascyllus marginatus. The Red Sea sub-species differs from that of the Indian Ocean in the tendency to have fewer pectoral rays, relatively longer soft dorsal and anal fins, and generally lesser developed pigmentation.

Oxymonacanthus halli. Differs from *O. longirostris* from the Indo-Pacific in having fewer dorsal, anal, and pectoral rays. There are also differences in the colour pattern.

It is interesting to consider these differences in relation to present data concerning the correlations of character with environment in fishes. It is well known that the number of fin rays and scales often appears to be inversely related to the temperature with which the above data appear to be in agreement. But a study of the charts of surface temperatures contained in the Monthly Meteorological Charts of the Indian Ocean (M.O. 519. H.M. Stationery Office) shows that from January until May northern Red Sea waters are consistently cooler than those of the Indian Ocean, while evidence is accumulating that many Red Sea fishes spawn during January and February—a problem to be discussed more fully in a later paper. On the other hand, the number of parts of a fish may have a direct relationship with salinity. Precisely what would be the apparent effect of high temperatures and increased salinities on numbers of fin rays or scales in Red Sea fishes (compared to their nearest relatives from the Indian Ocean) is impossible to predict. However, recent work by Heuts (1949) showing the combined effect of temperature and salinity on the number of fin rays in *Gasterosteus aculeatus* may be of particular significance here. Considering only the marine B population, increase in salinity at 10° C. led to an increase in the mean number of dorsal and anal rays, whereas at 23° C. the effect of this was to produce a decrease.

Concerning body form, Hubbs (1940) states that: 'Forms of warmer water, and in the sea those of brackish water, typically have deeper bodies and larger heads than

those of colder or more saline waters.' In the Red Sea there may be a correlation with the increased salinity for in three of the examples listed above, the Red Sea form had a slimmer body shape. More data are desirable before arriving at any conclusions, but these are interesting problems and further comparative studies of Red Sea and Indian Ocean fishes may well contribute to a closer understanding of them. At the same time experimental studies would be desirable. It need only be added that close correlation between environment and structure need not mean that the changes are entirely dependent on the environment. There is evidence from other work that the genotype is also involved. It will be apparent from the recognition of certain sub-species and the trend of this discussion that the view is held that it is unlikely that these correlations solely arise from the action of the environment on the phenotype.

To conclude, it looks as though partially enclosed seas, such as the Red Sea, may be centres for the evolution of new forms. I am much indebted to Dr. A. E. Parr for drawing my attention to the Gulf of California, which also harbours certain endemic species and sub-species. Setchell (1937), referring to earlier work in the gulf, points out that fifteen species or varieties of *Sargassum* are endemic, '. . . thus indicating what is borne out by the remaining marine flora of this body of water, that it forms a "pocket" of more than ordinary distributional interest'. Burkenroad (1938) notes that certain penaeid prawns are confined to the Gulf of California, while Parr (1931) took certain species of deep-sea fishes in the gulf that had originally been described from there by Garman (1899) and have not so far been taken outside this area (although neighbouring areas have been well worked).

More hydrological and biological data will be necessary to discover the degree of isolation of the fauna of these marine pockets. Mayr (1942) has remarked that: 'In the sea isolation is rarely complete and the partially isolated populations are normally very large. It is mainly for this reason that marine species have fewer sub-species than terrestrial species and that the entire evolution in the sea is slower and more conservative.' Further work on partially enclosed areas should help towards an understanding of the evolution of new forms in the seas.

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PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

ON THE SPECIES AND RACES OF THE YELLOW WAGTAILS FROM WESTERN EUROPE TO WESTERN NORTH AMERICA

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and
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Pp. 253–268; Pls. 33–35

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 9 of the Zoology series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued July 1952 *Price Five shillings*

Drawn by H. Grönvold and C. E. Talbot Kelly.

Blue-headed Yellow-Wagtail, male
Budytes flavus flavus

Budytes flavus dombrowskii, male

Yellow Wagtail, male
Budytes luteus luteus

Budytes luteus flavissima, male

Dark-headed Yellow-Wagtail, young
Budytes thunbergi thunbergi

Black-headed Yellow-Wagtail, young
Budytes feldegg

Blue-headed Yellow-Wagtail, female
Budytes flavus flavus

Budytes flavus dombrowskii, female

Yellow Wagtail, female
Budytes luteus luteus

Dark-headed Yellow-Wagtail, male
Budytes thunbergi thunbergi

Black-headed Yellow-Wagtail, male
Budytes feldegg

White-browed Yellow-Wagtail
Budytes superciliaris

Blue-headed Yellow-Wagtail, young
Budytes flavus flavus

Yellow-browed Yellow-Wagtail, male
Budytes perconfusus

Yellow Wagtail, young
Budytes luteus luteus

Dark-headed Yellow-Wagtail, female
Budytes thunbergi thunbergi

Black-headed Yellow-Wagtail, female
Budytes feldegg

White-headed Yellow-Wagtail, male
Budytes leucocephalus

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(*Received 15.v.51*)

SYNOPSIS

An endeavour has been made to collect all the known relevant facts on this group and to show that it is not correct to place all the Yellow Wagtails in one species. The authors have based their main conclusions on adult males, and the measurements given are only of adult males from the breeding area, so that a true comparison can be given, and there can be no confusion with measurements of specimens from the non-breeding areas which may have been misidentified by us. It is perhaps of interest to note that the southern species have usually a white chin and throat and the Far Eastern tend to have a longer hind claw.

The normal migration route appears to be mainly north and south, although there is largely a tendency to a north-eastern to south-western movement.

Measurements appear to be of little value in determining the species and races except perhaps in the case of the hind claw of *B. thunbergi macronyx*.

There is still much to learn about this group, especially the exact breeding-ranges of the species and races.

It should be remarked that adult males of all species and races are inclined to have some olivaceous green on the crown, or yellow in *B. leucocephalus*, and a broken spotted collar in both sexes. These are not specific or racial characters and may be individual retention of juvenile plumages.

A total of 2,594 specimens have been examined.

MANY authors[1] have written on this group, adding considerably to our general knowledge, and several have described new races. We have lately had occasion to study these Wagtails critically, with especial regard to those species and races which occur in Africa during the non-breeding season. We found it necessary, however, to survey the whole group.

The usual English practice has been to place all as races of one species, *Budytes flavus* (Linnaeus), but several authors have divided them into a number of species. We have examined all the literature we can find, the large series of specimens in the British Museum collection, and had the kind loan of specimens from Colonel Meinertzhagen, Colonel Payn, Major Payn, M. Mayaud, Dr. K. H. Voous, the Copenhagen Museum, the South African Museum, the Royal Natural History Museum, Stockholm, and the Coryndon Museum, Nairobi.

We are of the opinion that the genus *Budytes* should be retained as these Yellow Wagtails have somewhat different habits to the Black and White Wagtails, and behave more like Pipits in many respects. It is very unfortunate that we are so out of touch with the Russian museums, as no doubt they have series of birds from the breeding areas which would have been most valuable to examine, but no doubt a number of them have been recorded in the Russian journals we have consulted.

The maps we give not only show the known breeding-areas and limits of movements in the non-breeding season, but also the comparatively vast areas in Europe and

[1] The bibliography at the end of this article covers the principal references on this group.

Asia from which no breeding birds have been recorded, and surely some of these—especially along the rivers—must hold ground suitable to the Yellow Wagtail, although Sushkin (1925) states that apparently none are found breeding in the lower part of the Kobdo basin.

Our long and very careful examination convinces us that those authors who recognize several species are correct, and the maps we give show that there is in several cases an overlap in breeding distribution, a fact supporting the recognition of species. We have divided this group into seven species and would remark that *Budytes flavus* becomes paler on the head as it goes eastward, the palest being a specimen from Lake Aral, and where the breeding area of this race and *B. f. beema* meet specimens show characters of both. We feel sure that *Budytes thunbergi*, *B. luteus*, and *B. feldegg* should be treated as species and that *B. superciliaris* and *B. leucocephalus* are also recognizable as distinct species. In the course of this examination we have decided to name a new race and a new species, one from Lake Alakul on the Mongolian border, west of Dzungaria, on a single male that does not fit in with any other Yellow Wagtail without an eyestripe, and the other from five adult male specimens that are all so exactly alike and with such distinct characteristics that it would be unbelievable they do not represent an undescribed species. On the original labels of two from Khartoum A. L. Butler recorded his opinion that they are 'possibly hybrids *M. f. rayi* and *M. flava*', and on the male from the Copenhagen Museum '*rayi* × *flava*?', but we do not think that this is so, as their characteristics do not fit in with what would be expected of such an intermediate and they are all exactly alike.

The Yellow Wagtails have been credited with being a very variable group and any specimen not fitting into the general rule was merely passed over as an aberrant. This we consider a mistaken and dangerous point of view liable to obscure completely the true picture. Individual variation there is, but within the species. We do not find this group particularly difficult to disentangle and we advance no theories about it (Johansen, 1946), having based our conclusions on the facts as shown by specimens and the recorded known breeding distribution. Young birds in their first plumage in all the species are more or less ashy above with dusky centres to the feathers; a blackish streak between the crown and light eyestripe; below more or less buffish white with a black moustachial stripe joining up to an almost perfect collar on lower neck. In *B. feldegg* the dusky centres to the feathers of the upper parts are broader and darker, and in the *B. luteus* group these markings are almost absent and there is a tendency to a yellow wash on the lower belly. In this dress they can be named from the local population in which they occur, as they do not apparently leave their breeding grounds until they have moulted into an immature (intermediate) dress. In this immature dress they are found in their non-breeding quarters, and as the species and races may occur in mixed flocks it is not easy to name them correctly.

Comparison with correctly identified adult females does reveal certain similarities by which the majority can be named, but no written description can give those small differences which the eye can spot when the group as a whole is closely and meticulously studied. Even so, every immature specimen can by no means be named with absolute certainty.

It has been said that there is a difference in length of tail between *B. flavus flavus* and *B. flavus beema* and other named races, but we have measured birds from the breeding areas and cannot agree that this is so.

The seven species which we recognize can be distinguished as follows:

A. A streak from base of bill to over and behind eye in male:

Budytes flavus (Linnaeus). Blue-headed Yellow Wagtail

Budytes flavus flavus (Linnaeus)

Motacilla flava Linnaeus, 1758, *Syst. Nat.* 10th ed.: 185, South Sweden. (For synonyms see Hartert, 1905, *Vög. Pal. Fauna*: 287.)

Adult male. A distinct white streak from base of bill to over and behind eye, very rarely indeed broken over the eye; head and neck and sides of face grey (variable individually); usually flecked with white on ear-coverts; usually some white on chin; rest of underparts bright yellow; sometimes some spots on lower neck. Wing 77–85, hind claw 6–11, tail 67–74 mm. Twenty-one males from breeding area measured, a total of 474 specimens examined.

The female has the head and neck more olivaceous; below, chin and neck buffish white; rest of underparts pale yellow; often with spots on lower neck.

Distribution: Breeding southern Norway, southern Sweden, southern Finland, eastern England (rarely) to northern, western, and central France, middle Europe and the Caspian Sea; in non-breeding season to Africa throughout and Arabia.

Mayaud, 1949, states that at Oléron, western France, intermediates occur between *B. flavus* and *B. fasciatus*. Through the kindness of Dr. Mayaud we have seen three breeding males, Mayaud Nos. 2333, 2334, and 2335, all taken in May, and consider them to be *B. f. flavus*.

In *British Birds*: 86, 1949, Stuart Smith and Ramsden record a variant yellow Wagtail breeding in the hills near Higher Disley in Cheshire in June. They do not quite agree as to the exact markings of the head of the male and, anyway, such sight records are most difficult to fix and are often not worthy of being recorded. It would appear that this is possibly another record of *Budytes f. flavus* breeding in England.

Budytes flavus beema Sykes

Budytes beema Sykes, 1832, *Proc. zool. Soc. Lond.*: 90, Deccan, India, of which *Budytes dubius vel anthoides* Hodgson, 1844, in *Gray's Zool. Misc.*: 83 (nom. nuda) and *Budytes brevicaudatus* Homeyer, 1878, *J. Orn. Lpz.*, 131, Etawah, north-western India, are synonyms.

Adult male: Head and neck pale french grey, variably darker or paler. In freshly moulted dress the mantle is lighter and yellower than in the breeding season. Wing 76–81, hind claw 9–10, tail 67–72 mm. Nine males from breeding area measured; a total of 320 specimens examined. Where this race meets the nominate race specimens may be placed in either. The female is not distinguishable from the nominate race.

Distribution: Breeding from the Ural Mts. and Caspian Sea to Tomsk and Turkestan; in non-breeding season to the Sudan, Kenya Colony, Nyasaland, Arabia, and

India. Main non-breeding quarters appears to be India. One specimen from Valencia, Spain in April.

Budytes flavus fasciatus Zander

Budytes fasciatus Zander, 1851, *Naumannia* **1** (4): 19, southern France, of which *Motacilla flava iberiae* Hartert, 1921, *Vög. Pal. Fauna* **3**: 2097, southern France, is a synonym, but if these Yellow Wagtails are placed in the genus *Motacilla* the latter name must be used as *Motacilla fasciata* (Zander) is preoccupied by *Motacilla fasciata* Bechstein.

Adult male: White streak from base of bill to over and behind eye; chin to neck in front white. Wing 75–82, hind claw 8–11, tail 67–72 mm. Fifty-seven males from breeding area measured, a total of ninety-six specimens examined. The female also has the chin to neck in front white; the head is duller grey and below, pale or buffish yellow, often with spots forming a sort of collar on the lower neck. In fresh dress the head is more olivaceous.

Distribution: Breeding Spain, Portugal, eastern Pyrenees to western areas of southern France as far east as the Camargue, the Balearic Islands, and Morocco; in non-breeding season to Italy, Morocco, Algeria, Tunisia, and French Sudan.

Wardlaw Ramsay, 1923 (*Birds of Europe and North-west Africa*: 61) states that this race breeds in Algeria, and this has been quoted by other authors. We cannot find any evidence in support of this. Mayaud (1949), states that along the south coast of France between the Pyrenees and Provence intermediates occur between *B. f. fasciatus* and *B. cinereocapillus*. Through the kindness of Dr. Mayaud we have examined four breeding males from the Etang de Salies and the Camargue, Mayaud's Nos. 729, 1059, 1066, and 1069. All these have a white stripe from base of bill to over and behind eye and are we consider *B. f. fasciatus*.

Budytes flavus dombrowskii Tschusi

Budytes flavus dombrowskii Tschusi, 1903, *Orn. Jb.*, **14**: 161, Pantelimon, Rumania.

Adult male: Differs from *B. f. flavus* in having the ear-coverts darker; chin usually white; upper throat often white. Wing 81–87, hind claw 8–10, tail 72–75 mm. Five males from the breeding area measured, a total of fifty-five specimens examined.

Distribution: Breeding Rumania and Serbia in Yugoslavia; in non-breeding season to Palestine, Iraq, and Africa as far south as the Sudan and Abyssinia.

The female apparently differs from that of the nominate race in having rather darker ear-coverts, but we have seen no specimens from the breeding area and without these it is wellnigh impossible to give the comparative female characters.

Budytes flavus plexus Thayer & Bangs

Budytes flavus plexus Thayer & Bangs, 1914, *Proc. New Engl. Zool. Cl.* **5**: 41, Nijni Kolynsk, Kolyma, eastern Siberia.

Adult male: A narrow white streak from base of bill to over and behind eye; head, neck, and sides of face dark grey; lores and ear-coverts blackish; chin white; throat yellow. Wing 83–84; hind claw 11–12, tail 72–75 mm. Two males from breeding

area measured, a total of forty-four specimens examined. Thayer and Bangs give wing 81–82, tail 68–70 mm. for two males.

The female has a duller grey head often with an olivaceous wash, and usually has the chest more or less washed with chrome yellow and some dark spotting.

Distribution: Breeding northern areas of western and eastern Siberia as far west as the Petchora River; in non-breeding season to Iraq, India, and China.

Budytes flavus zaissanensis Poljakow

Budytes flava zaissanensis Poljakow, 1911, *Messager orn. Mosk.*, 313: Lake Zaissan, west of Mongolian border, Turkestan.

Adult male: A narrow white streak from base of bill to over and behind eye; head slate grey; mantle olive-green; agreeing very closely with some specimens of *B. thunbergi* in these last two characters. Wing 77–84, hind claw 9–10, tail 67–78 mm. Two males from the breeding area measured, a total of nine specimens examined.

We have not examined the female nor can we find any description of it.

Distribution: Breeding Barnaul to junction of Altai and Irtysh Rivers and Lake Saissan; in non-breeding season to Sind, Punjab, and Bengal, India, Thailand, and West Java.

Remarks: Poljakow compares this race to *B. f. flavus* and *B. thunbergi*. Sushkin, 1925, gives wing 77–80, hind claw 9·3, tail 66–72·7 mm.

Budytes flavus angarensis Sushkin

Budytes flava angarensis Sushkin, 1925, *Proc. Boston, Soc. Nat. Hist.* **38**: 33, Sharagolo-Kaia, Chikoi River, Transbaikalia.

Adult male: A white streak from base of bill to over and behind eye; mantle and borders of wing coverts less bright than *B. f. zaissanensis*. Wing 78–83, hind claw 9·5–13, tail 72–74 mm. (Sushkin).

Distribution: Breeding Lake Yevsi, Tunguzka and Angara Rivers to Lake Baikal, and the Chikoi River; in non-breeding season to China and Thailand.

We have not seen any specimens from the breeding area, but an adult male with a narrow white streak from base of bill to over and behind eye, which does not fit in with any other Eastern race, we consider is attributable to this race. It is from Pekin and was taken in May: Brit. Mus. Reg. No. 1949–9–243. Wing 80, hind claw 9, tail 71 mm., and an adult male from Bangkok, Thailand, taken on 20 April 1931, now in Raffles Museum, agrees with this specimen. Sushkin has compared *B. f. angarensis* to *B. flavus*, *B. simillimus*, and *B. zaissanensis*. The two immature birds mentioned by Sushkin, 1925, taken in the Ordos area are probably of this race, but no date or measurements are given nor is any mention made about an eye stripe. The characters given are insufficient to determine them and both are evidently in immature dress as they are stated to be moulting from the young dress. It would therefore appear that they were bred in that area, and maybe *B. f. angarensis* breeds as far south as Ordos.

Budytes flavus simillimus Hartert

Budytes flava simillimus Hartert, 1905, *Vög. Pal. Fauna*, **1**: 289, Kamschatka, Siberia.

Adult male: A white streak from base of bill to over and behind eye; head and nape rather darker grey than *B. f. plexus*; lores and ear-coverts as in *B. f. plexus*; mantle darker, more olive, less yellow-green. Wing 80–82, hind claw 9·5–11, tail 64–69 mm. Three males from breeding area measured, a total of 319 specimens examined. The female has the head olivaceous ashy slightly contrasting with the mantle; below, white or buffish-white; lower belly washed with pale yellow. Hind claw often longer than the females of other races. The immature dress is ashy above, often slightly olivaceous; rump greyer; below, creamy white; chest buffish; under tail-coverts often washed with pale yellow. In this dress it can be confused with *Budytes citreola* Pallas, though this species has a faint wash of yellow or buff on the forehead and the notch on the third primary 18–20 mm., up the feathers from the tip, this notch lying between the 7th and 8th primary, whereas in this race the notch on the 3rd primary is 15–16 mm., from the tip and lies between the 5th and 6th primary (see Sushkin, 1925).

Distribution: Breeding Kamschatka; in non-breeding season to India, as far west as the Punjab, Ceylon, Nicobar and Andaman Islands, China, Malay States, Philippine Islands, Dutch East Indies and New Guinea.

Budytes flavus tschutschensis (Gmelin)

Motacilla tschutschensis Gmelin, 1789, *Syst. Nat.* **2**: 962, Tschutschi coast, Bering Strait, eastern Siberia, of which *Budytes flavus alascensis* Ridgway, 1903, *Proc. Biol. Soc. Wash.* **16**: 105, Western Alaska, is a synonym.

Adult male: A white streak from base of bill to over and behind eye, broader than in *B. f. plexus*; head and sides of face dark grey; mantle darker than other races; chin and upper throat usually white; dusky spots on lower neck; below, more lemon-yellow, not bright canary yellow as in *B. f. simillimus* and *B. f. plexus*. Wing 76–81, hind claw 10–11, tail 66–71 mm. Four males from breeding area measured, a total of twenty specimens examined. The female is similar to the male, but perhaps slightly duller.

Distribution: Breeding north-eastern Siberia and Alaska; in non-breeding season to the Philippine Islands, West Java, and Dutch New Guinea.

Remarks: The two males from the Philippine Islands and one male from Dutch New Guinea, Brit. Mus. Reg. No. 1888.7.12.534 dated November, Brit. Mus. Reg. No. 1897.12.11.43 dated September, and Brit. Mus. Reg. No. 1916.5.30.857, dated December, agree with this race in general colour and the paler, more lemon-yellow colour below and not with males of *B. f. simillimus*.

Budytes luteus (Gmelin). Yellow Wagtail

Budytes luteus luteus (Gmelin)

Parus luteus Gmelin, 1774, (S. G.) *Reise durch Russland*, **3**: 101, pl. 20, fig. 1, Astrakan, southern Russia, of which *Motacilla campestris* Pallas, 1776, *Reise versch. Prov. Russ. Reichs*, **3**: 696

Russia; and *Budytes flava* var. *flavifrons* Sewertzow 1873, Vert. Geriz. Rashred. Turkest. Zhivoth, *Mém. Soc. Amis Sci. Nat. Moscou*, **8** (2): 67. Turkestan (nom. nuda), 1875, *Stray Feathers*, **3**: 424; and *Budytes chlorocephalus* Brehm, 1851, *Naumannia*, **2**: 24, Reuthendorf, are synonyms.

Adult male: Head yellow-green; forehead, and streak from base of bill to over and behind eye, yellow. Wing 75–87, hind claw 8–11, tail 66–70 mm. Eight males from breeding area measured; a total of 105 specimens examined. The female is difficult to distinguish from that of *B. f. flavus*, but it can be said that those with a more uniform head and mantle are this species and those with a greyish head contrasting with the mantle are *B. f. flavus*.

Distribution: Breeding from the Volga River to the headwaters of the Yenisei River; in non-breeding season to central, eastern, and southern Africa as far south as the Transvaal, Socotra Island, Arabia, India, and Ceylon.

Budytes luteus taivanus Swinhoe

Budytes taivana Swinhoe, 1863, *Proc. zool. Soc. Lond.*: 234, Formosa Island.

Adult male: Top of head green, uniform with mantle; lores to ear-coverts olivaceous black; a broad yellow streak from base of bill to over and behind eye; chin and throat bright yellow. Wing 76–87, hind claw 10–13, tail 67–75 mm. The female differs from the male in being duller in colour. The immature dress can be distinguished from that of *B. f. simillimus* by the yellow in the eye stripe. Twenty males from breeding area measured, a total of eighty-two specimens examined.

Distribution: Breeding from the Lena River and Ija River west of Lake Baikal to the Amur River, also Sakhalin and Kurile Islands, in non-breeding season to Burma, China, Formosa, the Malay Peninsula, Borneo and Dutch East Indies.

Budytes luteus flavissimus (Blyth)

Motacilla flavissima Blyth, 1834, *Loudon's Mag.* **7**: 342, England; of which *Budytes rayi* Bonaparte, 1838, *Geog. & Comp. List Birds Europe & S. Amer.*: 18, British Islands; *Budytes verna* (S.D.W.) Wood, 1835, *Analyst*, **3**: 31; 1836, 203; 1836, **4** (16): 296. Great Britain, nom. nuda; *Budytes verna* Wood, 1836, *Brit. Birds*: 219, *Motacilla flaveola* Temminck, 1835 *Man. d'Orn.* 2nd ed. 3: 180, England, are synonyms. For other synonyms see Hartert, 1905, *Vög. pal. Fauna*, **1**: 294.

Adult male: Differs from *B. l. luteus* in having the forehead uniform in colour with the crown of the head. Wing 72–87, hind claw 8–11, tail 64–74 mm. The female is similar to that of *B. l. luteus*. Fifty-four males from breeding area measured, a total of 233 specimens examined.

Distribution: Breeding southern Norway, southern to eastern British Isles (rarely west Wales, Cornwall, and Devon), Heligoland in most years (Drost, 1948), western Holland, western Belgium, northern France, and Channel Islands; in non-breeding season to Africa as far south as the Belgian Congo and Southern Rhodesia.

Breeds alongside *B. f. flavus* in southern Norway (see Bernhoft-Osa, 1944 and 1946), and at Dunkirk, Pointe de Raguenes near Nevez, Finisterre, north-western France (see Mayaud, 1949, *Ibis*: 171). Dr. Holger Holgersen found it breeding in southern Norway in 1947 and 1949 and considers it to be a regular summer breeder.

Budytes superciliaris Brehm. White-browed Yellow Wagtail

Budytes superciliaris Brehm, 1854, *J. Orn. Lpz.*: 74, Khartoum, Sudan; of which *Budytes leucostriatus* Homeyer, 1878, 128, Lake Baikal area; *Motacilla xanthophrys* Sharpe, 1885, *Cat. Birds. B.M.* **10**: 532, pl. 8, fig. 6, Lenkoran, Azerbaijan, southern Russia; and *Motacilla flava raddei* Harms, 1909, *Orn. Mber.* **17**: 2; Aschabad, Transcaspia, are synonyms. Hartert, 1905, *Vög. pal. Fauna*, **1**: 293, considers *M. f. raddei* to be an aberrant *B. l. taivanus*. Although we have not seen the type of *Budytes leucostriatus*, Homeyer gives the head as clear grey-black with a broad white stripe from the base of the bill to over and behind the eye. These characters agree with *B. superciliaris* and not with *B. l. taivanus* of which it is placed as a synonym by Hartert, 1905, *Vög. pal. Fauna*, **1**: 298.

Adult male: Top of head to nape jet black to grey-black; nape often grey; centre of crown to nape often olive-green; a white or yellow streak from base of bill to over and behind eye; lores and ear-coverts black with usually some white flecking on latter and under eye; chin white. Wing 77–85, hind claw 10, tail 66 mm. Two males from breeding area measured; a total of thirty-five specimens examined. The female can be distinguished from that of other species by the grey head and mantle with only a slight wash of olivaceous green; below, creamy white with a variable pale yellow wash from lower neck to under tail-coverts; eye-streak buff or buffish white; some spotting at base of neck. The immature dress is very similar to that of the adult female.

Distribution: Breeding southern Iran to Turkestan, also Bulgaria and eastern Yugoslavia; in non-breeding season to Egypt, the Sudan, Abyssinia, Arabia, and India.

Col. Meinertzhagen (1949, *Ibis*: 472) records seeing a party of four males near Taif, Arabia, sometime between February and April.

Budytes leucocephalus Przevalski. White-headed Yellow Wagtail

Budytes leucocephalus Przevalski, 1887, *Zap. Imp. Akad. Nauk. S.-Peterb.* **55**: 85,[1] Dzungaria, northern Turkestan.

Adult male: Whole head to nape, chin and usually upper part of throat white, or white washed with grey; sometimes a white eye-stripe is distinguishable. Wing 81, hind claw 10, tail 72 mm. One male from breeding area measured; a total of thirty specimens examined. The female is similar to the male. The immature bird has the head and ear-coverts olivaceous grey; a white streak from base of bill to over and behind eye; mantle washed with grey; below, chin and throat whitish washed with yellow; a broken spotted collar at base of neck; chest to under tail-coverts paler yellow than adult.

Distribution: Breeding eastern Russia, Turkestan, and western Mongolia; in non-breeding season to Africa as far south as north-eastern Northern Rhodesia and northern Nyasaland, Arabia and north-western India.

Remarks: Sushkin found the character of the head constant in the breeding area at Lake Achit-Nor. The specimens we have examined have a remarkable close resemblance to each other and it should be noted that the sexes are alike, facts which have induced us to place it as a species and not as a very pale headed race of *B. flavus*. We have examined thirty-one adult specimens, four of which are females,

[1] This Russian version of the *Mémoires* is apparently not available in Great Britain.

including one male in the Meinertzhagen Collection from Orox Nor in May, and compared them with the coloured Plate 10 of the male and female in Bianki 1905, *Wiss. Res. Przevalski Cent. Asien*, Zool., **2,** Vög. pt. 4, and find they agree very well with that plate, but it would appear the female figured is in immature dress. Finsch saw light-headed Yellow Wagtails, probably of this species, between the eastern end of Lake Zaissan and the Altai on 6 June, but none were obtained nor are they recorded as breeding there (see Suchkin, 1925). A description of this species was also published in *Ibis*, 1887: 401, but the one in the Russian journal has priority of date. Through the kindness of Dr. Barnard, Director of the South African Museum, we have had on loan the specimen recorded in *J. S. Afr. Orn. Un.* **2:** 92 (1906), from Kanyani, Northern Rhodesia, as '*Motacilla flava beema*?' and find that it agrees perfectly with the Brit. Mus. series of this species:

Budytes perconfusus Grant & Praed. Yellow-browed Yellow Wagtail

Budytes perconfusus Grant & Praed, 1949, *Bull. Brit. orn. Cl.* **69:** 130, Khartoum, Sudan.

Adult male: Above mantle rather darker than *B. luteus* and below rather paler yellow; chin and throat yellow; forehead to forecrown grey; a clear grey collar on hind neck; crown olive-green; a broad pale yellow streak from base of bill to over and behind eye; lores to ear-coverts darker grey with white flecking. Differs from *B. flava* in the yellow streak over the eye and the paler grey head. Wing 78–85; hind claw 9–11; tail 68–70 mm.

In fresh dress the forehead and nape is more washed with olivaceous green; the mantle is darker; the tips of the wing-coverts brighter yellow-green and only a few white flecks on the ear-coverts; streak over eye yellow, not white or buff or washed with buff, as in *B. flavus flavus* in fresh dress.

The female and young bird also have a yellowish eye streak.

Distribution: Known only from scattered specimens from Frederikhavn, north-eastern Denmark, Pomerania, Germany, Wassenaar near The Hague, Holland, Abyssinia, the Sudan, and western Arabia.

As stated above the five adult male specimens are exactly alike; the two from Khartoum, Brit. Mus. Reg. Nos. 1915.12.24.1429 and 1436 and Pomerania, Brit. Mus. Reg. No. 1941.5.30.819, were taken in April, the one from Denmark was taken on 3 May, and the one from Holland was taken in September. In the non-breeding season this species visits Abyssinia, the Sudan, and western Arabia and passes through Holland, Denmark, and Pomerania. A total of ten specimens examined, including a male from Fashoda, Sudan, March, Brit. Mus. Reg. No. 1902.4.20.142; a male from Khartoum, Sudan, December, Brit. Mus. Reg. No. 1915.12.24.1445; two males from Abyssinia, February and November, Brit. Mus. Reg. No. 1927.11.5. 653, and 1934.8.9.352; and a female from Arabia, September, Brit. Mus. Reg. No. 1935.5.10.78. We had considered placing it as a race of *B. flava*, but we feel that it is better treated as a species. We are confident that one day the breeding area will be discovered.

B. No streak from base of bill to over and behind eye in male, though sometimes a short white mark behind eye:

Budytes thunbergi (Billberg). Grey-headed Yellow Wagtail

Budytes thunbergi thunbergi (Billberg)

Motacilla thunbergi Billberg, 1828, *Syn. Faun. Scand.* **1** (2) Aves: 50, Lapland. For synonyms see Hartert, 1905, *Vög. pal. Fauna* **1:** 291.

Adult male: Head dark grey to near coal black; no streak over eye, occasionally a short white mark behind eye; more rarely a similar mark in front of the eye; chin and throat yellow; some spotting on lower neck in front. Wing 80–85, hind claw 8–11, tail 69–74 mm. Twenty-seven males from the breeding area measured; a total of 243 specimens examined. The female and immature are practically indistinguishable from that of *B. flavus flavus*, though perhaps some have rather a darker coloured top to the head.

Distribution: Breeding northern Norway and northern Sweden to Finland and northern Russia as far east as the lower Yenisei River, also Estonia; in non-breeding season to Africa as far south as Damaraland and the Transvaal, Arabia, India, Burma, and the Malay Peninsula.

Remarks: S. Armington 1949, records at Ladugardsgarde, north-east of Stockholm, having observed a male Yellow Wagtail in the summer of 1947 which agreed perfectly with *B. thunbergi*. This bird was with a female which was indistinguishable from the female of *B. f. flavus*, but the nest was not located. About twenty pairs of *B. f. flavus* were breeding in the same locality. At the same place in 1949 Armington observed a male and female, the male agreeing with *B. thunbergi*, but had a superciliary streak over the right eye and a small patch behind the left eye. It is difficult to comment on the above, as there are no specimens to examine, but would remark that as *B. thunbergi* breeds in Finland and Estonia, it could be found breeding on the same latitude near Stockholm.

As many females of both *B. thunbergi* and *B. flavus* are practically indistinguishable in skins and quite indistinguishable in the field, it cannot be said that the female with the Ladugardesgarde male was other than a *B. thunbergi*. As regards the male seen in 1949 as having a stripe over the right eye, this may have been a retention of the immature dress, but there is no proof that this is so.

Jordans, 1923, mentions fifteen males of *B. f. flavus* taken near Upsala, Sweden, in May with varying coloured heads from pale grey to a darker or lighter crown, all having a superciliary stripe, and a series from Lapland which varies in a similar way, of which the lightest matches the darkest *B. f. flavus*, and others show all intergradations from this type to an almost black crown. Twenty per cent. have a light superciliary stripe indicated or even quite distinct. Count Gyldenstolpe has kindly picked out five representative specimens from this series and sent them to us for examination, and remarks in a letter to us dated 4 October 1949, '*B. f. thunbergi* is found at Upsala during its migrations in May, together with *B. f. flavus*, hence the statements made by Jordans'.

All these five specimens are clearly *B. thunbergi thunbergi*; the Lapland ones all taken in June and the Upsala ones on 6 and 12 May. One from Lapland, taken on 16 June 1931, which has the dark head and ear-coverts of *B. t. thunbergi* has an indication of a white streak before as well as behind eye, but not over the eye. All

have some spotting on the lower neck in front. It would appear that Jordans considered this Lapland specimen of 16 June 1931 as an intermediate between *B. flavus* and *B. thunbergi*, but we are satisfied that this specimen is *B. thunbergi*, and not an intermediate between that species and *B. flavus*.

Budytes thunbergi cinereocapillus (Savi)

Motacilla cinereocapilla Savi, 1831, *Nuovo Giorn. Lett. Pisa*, **22**, 190, Tuscany, Italy.

Adult male: Differs from the nominate race in having the chin and neck in front white, or rarely some yellow mixed with the white on the lower neck in front. Wing 81–83, hind claw 9–11, tail 70–72 mm. Nine males from breeding area maesured, a total of thirty-one specimens examined. The female and immature are practically indistinguishable from those of *B. f. fasciatus*, both having a streak from the base of the bill to over and behind eye.

Distribution: Breeding southern France to Italy, Dalmatia, Switzerland, and Algeria; in non-breeding season to western, northern, and eastern Africa as far south as Senegal and Uganda, also Arabia.

Kirkman & Jourdain, 1913, *British Bird Book*, Vol. **4**: 477, state that this race breeds in Tunis, and this has been quoted by other authors. We cannot find any evidence in support of this.

Remarks: Thönen (1948) records and figures the head of a Yellow Wagtail breeding at Lake Neuenburger, near Basle, Switzerland.

This figure and the description agrees well with specimens in the British Museum collection of *Budytes thunbergi cinereocapillus* which has in some specimens the pure white more confined to the throat and a white fleck behind the eye. This figure was drawn from life, as the bird was not collected. Ticehurst and Whistler (1927) state that this race is found in the plains and *B. f. fasciatus* in the mountains, but Ticehurst obtained a male of *B. f. fasciatus* in June at Argelès-sur-Mer. It would thus appear that both breed in the same area. The single record of this race from Great Britain can be accepted. There is little doubt that it was collected near Marazion Station. The specimen has disappeared, but there is an excellent coloured figure of it in Gould's *Birds of Gt. Britain*, **3**: pl. 5, 1873.

Budytes thunbergi pygmaeus Brehm.

Budytes pygmaeus Brehm, 1854, *J. Orn. Lpz.*: 74, (note), north-east Africa.

Adult male: Similar to *B. t. cinereocapillus* but smaller in size; chin and throat sometimes yellow; often an olive-green patch on crown of head and a white streak behind eye. Wing 70–78, hind claw 8–10, tail 58–67 mm. The female is very similar to that of *B. t. cinereocapillus*, but is smaller; sometimes a white mark behind eye. Thirty-six specimens examined.

Distribution: Egypt.

Budytes thunbergi macronyx Stresemann.

Budytes flavus macronyx Stresemann, 1920, *Avifauna Macedonica*: 76, Vladivostock, eastern Russia.

Adult male: Differs from the nominate race in having a rather darker mantle and

a longer hind claw; chin white; sometimes a short white mark behind eye. Wing 78–84, hind claw 10–15, tail 69–75 mm. Fourteen males from breeding area measured, a total of seventy-one specimens examined. The female has the head olivaceous green or olivaceous grey; sometimes a short light mark behind eye. The immature dress is grey or olivaceous grey above and creamy white below.

Distribution: Breeding Siberia; in non-breeding season in China, Siam, Burma, Indo-China, Philippine Islands, Singapore, Borneo, Sumatra and Java.

Budytes thunbergi alakulensis Grant & Praed.

Budytes thunbergi alakulensis Grant & Praed, 1949, *Bull. Brit. orn. Cl.*, **69:** 131, Lake Alakul, Turkestan.

Adult male: Similar to *Budytes thunbergi thunbergi*, but head rather darker, more coal black. Wing 80, hind claw 8, tail 68 mm.

Distribution: Breeding Lake Alakul; in non-breeding season to Kiukiang, Yangtse River, China.

Two specimens examined.

Budytes feldegg (Michahelles). Black-headed Yellow Wagtail

Motacilla feldegg Michahelles, 1830, *Isis*: 812, Split, Dalmatia, Yugoslavia; of which *Budytes melanogrisea* Homeyer, 1878, *J. Orn. Lpz.*: 128, India; *Budytes aralensis* Homeyer, 1878, *J. Orn. Lpz.*: 128, Lake Aral (compared to *B. feldegg*, head given as coal black; below lemon yellow); *Budytes flava suschkini* Domaneiwski, 1925, *Ann. Mus. Zool. Polon*, **4:** 95 & 107, no type locality; and *Motacilla kaleniczenkii* Kaleniczenko, 1839, *Bull. Soc. Nat. Moscou*: 229, pl. 20, Crimea, are synonyms.

Adult male: Forehead to nape, sides of face, ear-coverts and sides of neck jet black to coal black; sometimes variable white streak between black face and yellow throat; chin and throat yellow; often some green on top of head and some grey at nape. Can be distinguished from *B. superciliaris* in having no streak from base of bill to over and behind eye. Wing 78–85, hind claw 9–11, tail 66–76 mm. Thirty-three males from breeding area measured; a total of 377 specimens examined. The female and immature plumages are similar to those of *B. superciliaris*, but there is no streak from the base of the bill to over the eye, though sometimes there is a short light mark behind the eye.

Distribution: Breeding in Montenegro, Serbia in Yugoslavia, Albania, Greece, Turkey, and Syria to the Black and Caspian Seas, Lake Aral, north-western Iran, and Turkestan; in non-breeding season to southern France, eastern Africa as far south as Uganda and Kenya Colony, southern Arabia, Socotra Island and India.

In adult females there is considerable individual variation on the head which does not appear to have any relation to the breeding and non-breeding season. These variations are well shown in Pl. 1, *Ibis*, 1932, though the black colouring in figs. 3, 4, and 5 is much too dull. Rarely males have the mantle grey with a slight olivaceous wash; below, chin and throat white with a faint touch of yellow; rest of underparts very pale yellow. A plumage very similar to some adult females. The four specimens

recorded from Great Britain have disappeared. We are of opinion that the claim that they were British taken should be viewed with grave suspicion.

We have to thank Dr. K. H. Voous for much kind help, and Dr. Holger Holgersen for translations from Norwegian journals.

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PLATE 34

1. *Budytes flavus flavus*
2. *Budytes flavus beema*
3. *Budytes flavus fasciatus*
4. *Budytes flavus dombrowskii*
5. *Budytes flavus plexus*
6. *Budytes flavus zaissanensis*
7. *Budytes flavus angarensis*
8. *Budytes flavus simillimus*
9. *Budytes leucocephalus*
10. *Budytes flavus tschutschensis*
11. *Budytes superciliaris*

PLATE 35

12. *Budytes luteus luteus*
13. *Budytes luteus taivanus*
14. *Budytes luteus flavissimus*
15. *Budytes perconfusus*
16. *Budytes thunbergi thunbergi*
17. *Budytes thunbergi cinereocapillus*
18. *Budytes thunbergi pygmaeus*
19. *Budytes thunbergi macronyx*
20. *Budytes thunbergi alakulensis*
21. *Budytes feldegg*
22. Known breeding distribution of all the Yellow Wagtails

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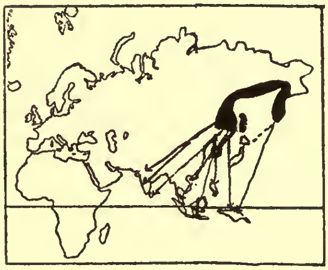

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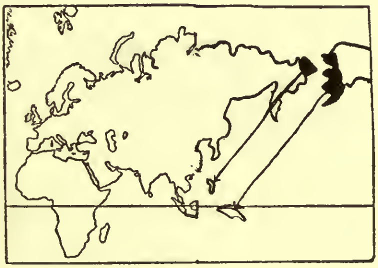

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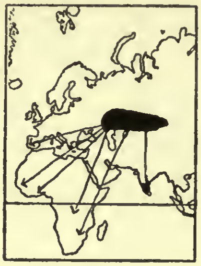

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GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

MAMMALS COLLECTED BY MR. SHAW MAYER IN NEW GUINEA 1932–1949

ELEANOR M. O. LAURIE

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ZOOLOGY Vol. 1 No. 10
LONDON : 1952

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BY

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Xuf

Pp. 269-318

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

Parts appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 10 of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

Issued December 1952 *Price Fifteen shillings*

MAMMALS COLLECTED BY MR. SHAW MAYER IN NEW GUINEA, 1932–1949

By ELEANOR M. O. LAURIE

SYNOPSIS

This paper gives a detailed account of a large collection of Mammals, mainly Marsupials and Rodents, from north-east New Guinea and eastern Papua (south-east New Guinea). Comparative descriptions are made of 13 new forms comprising 1 new genus (rodent), 7 new species (3 marsupials, 2 rodents, 1 bat, and 1 monotreme), and 5 subspecies (3 marsupials and 2 rodents).

DURING the years 1932–1949 Mr. Shaw Mayer made a collection of mammals in New Guinea. Most of the specimens came from localities of comparatively high altitude, where the hill-sides are covered with rain forest. Between 5,000 and 8,000 ft. the lower limit of the wet mossy forest is often reached. From 10,000 to 11,000 ft. is a drier zone of grassland and coniferous forest, the upper limit of the forests being at about 14,000 ft. A list of all the localities from which specimens were obtained is given in Appendix II. Most of them are in north-east New Guinea: the Hagen Range and Sepik-Wahgi Divide, 4,500–8,500 ft.; the Kratke Mountains and Upper Waria River district, 2,500–6,000 ft.; the Upper Ramu River Plateau, 6,000 ft.; Mount Wilhelm and Herowagi, Bismarck Range, 6,000–10,000 ft.; the Ramu Purari Divide which is south-east of the Bismarck Range, 7,500–8,000 ft.; and in eastern Papua, south-east New Guinea: Mount Simpson, Mount Mura (30 miles NW. of Mt. Simpson) and the Maneao Range (35 miles NW. of Mt. Simpson), 1,000–7,000 ft. (see Fig. 1). A few specimens, mainly rodents, were also collected from West Fergusson Island (which is about 40 miles from the mainland), between 600 and 3,000 ft. Many of these regions have not been investigated before, particularly those near the Bismarck Range and Mount Simpson.

The collection comprises 370 marsupials belonging to 29 species, 380 rodents belonging to 31 species, 31 bats belonging to 11 species, and 5 monotremes belonging to 3 species.

Among these specimens which are dealt with in this paper are 13 new forms: 6 marsupials (3 species and 3 subspecies), 5 rodents (1 genus, 2 species, and 2 subspecies), 1 bat (species), and 1 monotreme (species).

Most of the recent work on mammals of New Guinea has been done by G. H. H. Tate (1935–1951), using several valuable collections from Vogelkop, the Arfak Mountains, Humboldt Bay, the Weyland Mountains, Mount Wilhelmina, the Indenburg River, Fly River, Oriomo River, the Central Division of Papua, the Huon Peninsula, and from islands off the coast of New Guinea. An account of the rodents of Australia and New Guinea by Tate (1951) has been published while this manuscript was in the press. I have, however, been able to refer to it and in the main have followed his revised nomenclature. Accounts of many of the forms from New Guinea have been given by Thomas and also by Schlegel, Milne-Edwards, Matschie, Ramsay, Rothschild & Dollman, Hinton & Ellerman.

This account includes references to a few co-types and paratypes which have already been mentioned in their type descriptions but are included here as they are part of this collection.

FIG. 1. Map of eastern New Guinea showing localities near which specimens were obtained.

Amongst the commonest animals collected are the following:

MARSUPIALS: *Eudromicia caudata,* the Long-tailed Dormouse Phalanger; *Dactylopsila trivirgata melampus,* the Black-footed Striped Phalanger; *Dactylonax palpator,* the Long-fingered Striped Phalanger; *Phalanger vestitus,* a Cuscus; *Pseudocheirus c. cupreus* and *P. c. corinnae,* Ring-tailed Opossums (only from NE. New Guinea but previously recorded from both NE. and SE.); *Peroryctes longicauda ornata,* the Ornate Bandicoot (only from NE. New Guinea but previously recorded from both NE. and SE.); and *Satanellus albopunctatus,* the northern Native Cat which is now regarded as being synonymous with the southern form *daemonellus.* The Ring-tail Opossum *Pseudocheirus forbesi larvatus* also appears to be fairly common but is restricted to north-east New Guinea.

RODENTS: *Rattus exulans browni*, Brown's Island Rat, a small rat common in native huts; *Rattus ruber tramitius*, a common outdoor scavenger in native gardens and sometimes in huts; *Melomys rufescens rufescens*, a Mosaic-tailed Rat; *Pogonomys mollipilosus*, *Pogonomys sylvestris*, and *Pogonomys macrourus*, Prehensile-tailed Rats; and *Mallomys rothschildi*, a giant rat. *Melomys fellowsi*, a Mosaic-tailed Rat, *Crossomys moncktoni*, Monckton's Water-rat, *Hyomys goliath goliath*, one of the giant rats, and *Parahydromys asper*, a water-rat are also common, but in this collection have only been taken from north-east New Guinea though their range, apart from *Melomys fellowsi*, extends into north-east Papua.

Only a small number of bats were collected. They include, however, one new species of *Otomops*, which is of interest as this is only the second time that the genus has been recorded from New Guinea.

The Echidnas include one new species of *Zaglossus*.

The fauna of New Guinea is closely related to that of Australia. The great majority of the forms, however, are specific to New Guinea and the neighbouring islands.

Throughout this paper the specimen numbers given are the British Museum registered numbers unless otherwise stated.

Where there are a large number of specimens of a species the extremes, mean, and standard deviation which gives some idea of the variation from the mean, are given instead of the detailed measurements of each specimen.

I should like to take this opportunity of expressing my thanks to my colleagues in the Mammal Room for their help, especially to Dr. T. C. S. Morrison-Scott and to Mr. R. W. Hayman, who helped with the identification of the bats and has described the new *Otomops* in this paper.

MONOTREMATA

Zaglossus bartoni bartoni (Thomas)

Acanthoglossus bruijnii bartoni Thomas, 1907, *Ann. Mag. Nat. Hist.* 7: 294.
Type locality: Mount Victoria, Papua, 8,000 ft.

Two specimens, ?♀ 50.1453, ♂ 1452, from Bubu River district, NE. New Guinea.

Measurements in mm. (taken in the flesh) [Female first, male second]: Total length 600, 573; hind foot—, 62; weight 21¾ lb., 13 lb.; length of skull 175, 169; basal length 167, 158; breadth of braincase 55, 57; muzzle from level of lacrymal canal 110·3, 106·1; gnathion to back of palatal bones 154, 146; least inter-orbital breadth 20·0, 18·2; width of rostrum 40 mm. from tip 11·8, 11·4.

Zaglossus bubuensis sp. n.

Type locality: Bubu River district, NE. New Guinea, *c.* 7,000–8,000 ft.

Type: Adult ♂ 50.1454, collector's No. 544, 8 Nov. 1936. Skin and skull.

Similar to *bartoni* in having five claws on all the feet, in the spineless undersurface which, however, is only thinly covered with hair, and in the uniform whiteness of the short (max. length *c.* 32 mm.) spines. It differs from *Z. b. bartoni* in that its hair is brown, not black, and does not quite cover the spines on its back. The hair on the backs of all four feet is light brown.

Body measurements in mm. (taken in the flesh): Total length 656; hind foot 60; weight 17½lb.

The size and shape of the skull is somewhat similar to that of *Z. b. bartoni*, but the rostrum is not so curved.

Skull measurements in mm.:

	Total length	*Basal length*	*Breadth brain case*	*Muzzle from lacrymal canal*	*Gnathion to back of palatals*	*Inter-orbital breadth*	*Width rostrum 40 mm. from tip*
Type of *bubuensis*	177	167	57·5	108	156	17·1	12·4
Type of *bartoni*	184	174	59·5	115	161	20·0	13·0

Tachyglossus aculeata lawesi (Ramsay)

Echidna (*Tachyglossus*) *lawesi* Ramsay, 1877, *Proc. Linn. Soc. N.S.W.*, **2**: 32.
Type locality: Port Moresby, SE. New Guinea.

Juvenile ♀ 50.1450 (skull and piece of skin), Apimuri, Kratke Mts., NE. New Guinea; skull ♀ 50.1451, locality unknown but probably same as 50.1450.

MARSUPIALIA

Thylogale bruijni browni (Ramsay)

Halmaturus brownii Ramsay, 1877, *Proc. Linn. Soc. N.S.W.* **1**: 307.
Type locality: New Ireland.
Macropus lugens Alston, 1877, *Proc. Zool. Soc. Lond.* **1877**: 126.
Type locality: Duke of York Island or adjoining shores of New Britain or New Ireland.
Macropus tibol Miklouho-Maclay, 1885, *Proc. Linn. Soc. N.S.W.* **10**: 141.
Type locality: 'Maclay Coast' north of Finisterre Range and east of Madang.
Thylogale lauterbachi Matschie, 1916, *Mitt. Zool. Mus. Berl.* **8**: 290–292.
Type locality: Ogeramnag near Source of Bulung River.
Thylogale brunii brownii Ramsay, Tate, 1948, *Bull Amer. Mus. Nat. Hist.* **91**: 319–320.

Five specimens from NE. New Guinea: ♂ 50.1445, Arau, Kratke Mts.; juv. ♂ 1447, ♀ 1446, Buntibasa district, Krakte Mts.; ♂ 1449 (skull and piece of skin), Kambaidam, Kratke Mts.; ♀ 1448, Bubu River district.

Dorcopsulus vanheurni vanheurni (Thomas)

Dorcopsis vanheurni Thomas, 1922, *Ann. Mag. Nat. Hist.* **9**: 264.
Type locality: Doormanpad-bivak, N. New Guinea, 1410 m.
Dorcopsulus vanheurni vanheurni Thomas, Tate, 1948, *Bull. Amer. Mus. Nat. Hist.* **91**: 286–287.

Six specimens. Three from NE. New Guinea: ♂ 50.1434, Kuraka, Kratke Mts.; ♂ 1443, ♀ 1444, Saiko, Bubu River; and three ♀♀ 1140, 1141, juv. 1142, from Boneno, Mt. Mura, eastern Papua.

Two females, Nos. 1140 and 1141, and a male, No. 1434, are of interest as their pelage appears to be that of the fully adult animal, which differs from that of the

type, a young adult female, in being shorter, thinner, and of darker grizzled brown without the somewhat rufous colour.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind Foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals, length*	*Anterior palatal foramina*	p^4–m^4	m^{1-3}	p^4
50.1140	♀	446	347	107	40	74·9	46·1	33·3	4·0	27·8	13·6	9·6×3·5
1141	♀	413	320	103	40	70·5	42·7	32·1	4·6	28·0	13·6	9·6×3·4
1434	♂	341	402	100	39	74·0	44·2	33·0	5·4	27·0	13·5	9·0×3·5
1443	♂	395	298	96	37	69·1	43·2	31·8	2·5	26·3	13·4	8·1×3·2
1444	♀	375	295	98	38	70·0	42·7	31·5	4·6	26·9	13·4	8·5×3·5

Dendrolagus dorianus dorianus Ramsay*

Dendrolagus dorianus Ramsay, 1883, *Proc. Linn. Soc. N.S.W.* **8:** 17.

Type locality: Mount Astrolabe, SE. New Guinea.

Dendrolagus dorianus dorianus Ramsay, Rothschild & Dollman, 1936, *Trans. Zool. Soc. Lond.* **21:** 477–549.

Nine specimens. Seven from NE. New Guinea: ♂ 50.1427, 1428, 1423, juv. ♂ 1422, ♀ 1424, 1426, juv. ♀ 1425, south side Bubu River, NE. New Guinea; and two from eastern Papua: ♀ 1143, Enaena, NE. slopes Mt. Simpson; and ♀ 1144, Manaeo Range.

The colour of the pelage of these specimens varies from a dark brown, e.g. No. 1428, to a light greyish-brown, No. 1143.

Although the tail is non-prehensile the hairs on it in specimens Nos. 1143 and 1144 are worn down so that they are quite short and bristly. The tails of one or two of the specimens of *Dendrolagus* already in the Museum's collection also have this appearance.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	m^{1-3}	p^4	m^1	m^2	m^3	m^4
50.1143	♀	596	662	117	48	115·8	72·0	47·5×22·8	13·3	10·9×6·8	6·5×6·6	6·8×6·7	7·0×7·2	7·1×7·0
1426	♀	600	490	102	50	108·8	65·8	46·5×22·8	13·2	10·2×6·2	6·3×6·4	6·7×6·6	6·9×6·9	7·1×6·2
1424	♀	615	463	100	50	106·9	67·2	44·0×22·4	12·5	9·8×5·8	6·0×5·9	6·5×6·3	6·7×6·5	6·4×5·8
1423	♂	628	497	107	57	113·2	75·5	46·9×24·5	13·5	10·4×6·5	6·5×6·4	7·0×6·8	7·5×6·8	7·5×6·7
1144	♀	633	550	103	45	109·0	68·8	43·6×23·5	13·6	10·4×6·7	6·6×6·3	6·9×6·7	7·1×6·9	7·1×6·5
1427	♂	687	586	115	53	124·0	77·0	51·7×26·8	14·0	11·0×7·2	6·7×6·4	7·3×6·5	7·2×6·8	7·1×6·5
1428	♂	730	570	117	57	122·7	77·5	49·0×24·9	13·6	10·3×6·6	6·6×6·1	7·0×6·5	7·5×6·8	7·5×6·7

Dendrolagus dorianus shawmayeri Rothschild & Dollman

Dendrolagus goodfellowi shawmayeri Rothschild & Dollman, 1936, *Trans. Zool. Soc. Lond.* **21:** 484, 486.

Type locality: Kratke Mts., NE. New Guinea, 4,500 ft.

Dendrolagus dorianus shawmayeri Rothschild & Dollman, Tate, 1948, *Bull. Amer. Mus. Nat. Hist.* **91:** 237–351.

Six specimens. Five from NE. New Guinea: two co-types, juv. ♀ 50.1429, ♂ 1430 (skull only), from Arau, Kratke Mts.; juv. ♀ 1431 (skin only), Binemarian, Kratke

* For *D. d. notatus*, see Appendix III, p. 318.

Mts. ; sex 50.1432 (flat skin only), north side Bubu River; ♀ 1814, near Herowagi, south slopes Bismarck Range; and one flat skin (no number) from mountains of SE. New Guinea, behind the island of Samaria.

No. 1429 is the co-type mentioned by Rothschild & Dollman (1936), who also refer to another specimen, presumably No. 1431.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	m^{1-3}	p^4	m^1	m^2	m^3	m^4
50.1429	♂*	480	675	113	51	92·0	59·7	44·9×15·3	11·2	9·8×5·5	5·4×4·9	5·8×5·1	6·1×5·0	6·0×5·0
1430	♂	—	—	—	—	99·5	61·3	46·1×21·3	11·0	9·9×4·8	5·3×5·1	5·7×5·2	6·1×5·2	6·1×5·2
1814	♀	—	—	—	—	100·3	63·7	44·0×19·7	11·9	9·6×5·0	5·7×5·3	6·0×5·5	6·2×5·5	6·0×5·4

* juvenile

Distoechurus pennatus neuhaussi Matschie

Distoechurus neuhaussi Matschie, 1916, *Mitt. Zool. Mus. Berl.* **8:** 292.
Type locality: Sattelberg Mts., Huon Gulf, Dutch New Guinea.
Distoechurus pennatus amoenus Thomas, 1920, *Ann. Mag. Nat. Hist.* **6:** 537.
Type locality: Rawlinson Mts., New Guinea.
Distoechurus pennatus neuhaussi Matschie, Tate & Archbold, 1937, *Bull. Amer. Mus. Nat. Hist.* **73:** 388–390.

Ten specimens. Four from eastern Papau: ♂ 50.1073, ♀ 1076, 1074, 1075, Enaena, (1076 from Ikara), NE. slopes Mt. Simpson; and six from NE. New Guinea: ♂ 1387, ♀ 1388, 1389, Buntibasa district, Kratke Mts.; and ♀ 1811, juv. ♀ 1812 (in pouch of 1811), Yandara, Bismark Range; ♂ 1813, Guyebi, Bismarck Range.

This series extends the range of *neuhaussi* from the Sepik River area, NE. New Guinea (Tate & Archbold, 1937) to Mt. Simpson, eastern Papua. Very slight differences in the general colour of the specimens from the three localities can be noted. Those from eastern Papua are a uniform light brown, those from the Kratke Mts. slightly darker and more ochraceous, and those from Yandara and Guyebi (Mt. Wilhelm) slightly darker and greyer, though No. 1813 is hardly distinguishable from those from eastern Papua.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*
50.1075	♀	108	137	20	12	26·1	17·2	5·8	11·5×3·8	15·4	3·2
1076	♀	109	136	20	11	25·9	17·2	5·8	11·4×3·3	16·0	3·2
1074	♀	110	152	21	11	27·0	17·1	5·7	11·6×3·9	16·0	3·3
1073	♂	113	145	21	12	26·8	17·7	6·0	12·8×3·5	16·5	3·3
1387	♂	103	136	20·5	12	26·9	17·5	6·0	— ×3·4	—	3·5
1389	♀	109	149	21	12	27·9	19·2	6·7	12·7×3·7	16·5	3·6
1388	♀	116	142	21	13	28·6	19·2	6·5	12·5×3·6	17·0	—
1813	♂	112	148	20	12	27·6	19·7	6·3	12·1×4·0	—	3·5
1811	♀	120	142	21	11	28·1	18·6	6·1	11·9×4·6	16·9	3·7

Eudromicia caudata (Milne-Edwards)

Dromicia caudata Milne-Edwards, 1877, *C. R. Acad. Sci., Paris,* **85:** 1079–1080.
Type locality: Arfak Mountains, Dutch New Guinea.
Eudromicia caudata (Milne-Edwards), Tate & Archbold, 1937, *Bull. Amer. Mus. Nat. Hist.* **73:** 384–385.

Fourteen specimens. Eleven from NE. New Guinea: ♂ 50.1390, ♀ 1391, Saiko, Bubu River; ♂ 1083, ♀ 1084, 1085, 1086 (skin only), Tapu, Upper Ramu River Plateau; ♂ 1080, 1081, ♀ 1082, Baiyanka, SE. Bismarck Range; ♂ 1827, Yanka, eastern slopes Hagen Range; ♀ 1828, Yandara, Bismarck Range; and three from eastern Papua: ♂ 1077, ♀ 1078, Enaena, NE. slopes Mt. Simpson; ♀ 1079, Boneno, Mt. Mura.

The colour of the pelage of all the specimens is very similar and although Nos. 1390, and 1391 from the Bubu River are larger than the others their measurements are very similar to those given by Tate & Archbold (1937) for *caudata* from Matsika, Papua.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	m^{1-3}
50.1390	♂	97	163	18	18·5	25·2	17·6	5·4	11·7×3·6	15·6	2·4	4·0	4·6
1391	♀	106	174	18·5	20	25·8	18·0	5·2	11·5×3·9	15·5	2·1	4·0	4·6
1083	♂	92	144	17	18	23·5	15·8	5·3	11·5×3·5	14·6	2·0	3·7	4·2
1084	♀	92	145	17·5	17	—	16·0	5·7	10·5×3·6	14·4	2·0	3·7	4·3
1085	♀	99	138	17	19	23·8	16·6	5·6	12·0×3·7	14·8	2·0	4·0	4·3
1080	♂	98	147	18	18	24·2	16·0	5·5	12·1×3·9	14·6	—	3·9	4·5
1081	♂	94	140	17	18	23·2	15·6	5·2	11·2×—	14·4	2·0	3·8	4·3
1082	♀	97	148	17·5	17	23·9	16·1	5·3	— —	14·9	2·1	3·7	4·4
1077	♂	101	153	18·5	20	22·6	15·4	5·0	11·0×3·4	13·8	2·0	3·6	4·1
1078	♀	92	143	17·5	18	23·9	16·0	5·4	11·8×3·7	14·6	2·0	3·8	4·1
1079	♀	95	148	18	19	24·2	16·0	5·0	10·8×3·9	14·9	2·0	4·0	4·3
1827	♂	108	145	19	18	25·1	17·1	5·1	11·6×3·7	15·5	2·0	3·9	4·2
1828	♀	94	140	18	18·5	24·0	16·7	5·4	11·3×3·7	—	2·2	—	4·1

Dactylopsila trivirgata melampus Thomas

Dactylopsila melampus Thomas, 1908, *Ann. Mag. Nat. Hist.* **1:** 122.
Type locality: Kokoda, Mambare River, SE. British New Guinea.
Dactylopsila hindenburgi Ramme, 1914, *S.B. Ges. naturf. Fr. Berl.* **1914:** 413.
Type locality: Sattelberg, NE. New Guinea.
Dactylopsila biedermanni Matschie, 1916, *Mitt. Zool. Mus. Berl.* **2:** 303.
Type locality: Upper Aroa River, Papua.
Dactylopsila trivirgata melampus Thomas, Tate & Archbold, 1937, *Bull Amer. Mus. Nat. Hist.* **73:** 393.

In all fifty-five specimens. Thirty-six from NE. New Guinea: twenty of these from the Kratke Mts.; ♂ 50.1305, juv. ♂ 1304, ♀ 1307, 1306, Arau district; ♂ 1291, ♀ 1292, juv. ?1293, Kambaidam; ♀ 1302, juv. ♀ 1301, Apimuri (Buntibasa district);

juv. ♂ 1303, Yampara; ♂ 1297, 1296, 1295, 1294, ♀ 1300, 1299, juv. ♀ 1298, Buntibasa district; ♂ 1309, 1308, juv. ♀ 1310, Kuraka; twelve from near the Upper Waria River: ♂ 1322, Bubu River district; ♂ 1313, ♀ 1314, 1318, 1319, 1320, 1321, juv. ♀ 1316, juv. ♀ 1317, juv. ♂ 1311, juv. ♂ 1312, juv. ♀ 1315, Garaina; one ♂ 1014 from Baiyanka, SE. Bismarck Range; ♀ 1822 from Guyebi, Bismarck Range; and three, juv. ♂ 1819, ad. ♀ 1820, juv. ♀ 1821, from Menebe, 8 miles east of Hagen Range, Sepik-Wahgi Divide. The following eighteen specimens are all from eastern Papua: ♀ 1017, juv. ♀ 1018, juv. ♀ 1016, Ikara, NE. slopes Mt. Simpson; ♂ 1019, 1020, ♀ 1022, 1024, 1025, 1026, 1027, 1028, juv. ♀ 1023, Enaena, NE. slopes Mt. Simpson; young ad. ♂ 1034, juv. ♂ 1035, ♀ 1036, Boneno, nr. Mt. Mura; ♂ 1030, ♀ 1031, Wapona, N. slope Maneao Range.

This excellent collection of skins shows a great deal of variation in the length of hair. This is very obvious in the series from the Kratke Mts., which have on the whole longer hair and bushier tails than those from other parts of NE. New Guinea and eastern Papua, though one or two of these are similarly long haired. It is particularly marked in the young specimens. In No. 1301 the hair on the rump reaches a maximum for any specimen of about 8 cm. in length. Two specimens, juv. ♂ 1819, ad. ♀ 1820, collected by Mr. Shaw Mayer in 1946 at Menebe, Sepik-Wahgi Divide, NE. New Guinea, 6,000 ft., about 120 miles to the north-east of the Kratke Mts., also have long hair and bushy tails. It may be that the length of the hair is associated with the age of the animal, as on the whole larger specimens have shorter hair.

The amount of greyish hair in the tail varies from virtually none (Nos. 1310, a very dark specimen, 1293, 1294, and 1295, all from the Kratke Mts.) to about two-thirds (Nos. 1297 and 1322). Several specimens (mostly females) have white tips to their tails (♀ 1307, 1306, 1299, 1018, young, of black tipped, ♀ 1017, 1022, 1023, 1024, 1036, ♂ 1313, 1020, 1014)

Specimen No. 1020, an adult ♂, is of interest as the black chin spot is divided in two by a white stripe running from the throat to the middle of the lower lip, as in typical *trivirgata* or *t. infumata*. In every other respect it is typical *melampus*.

The following are the measurements in millimetres of fourteen adult males and twenty-two adult females of *melampus*:

	Extremes		*Average*		*Standard deviation*	
	♂	♀	♂	♀	♂	♀
Head and body	233–287	220–327	249	246	13·1	10·3
Tail	263–398	243–382	348	344	29·3	25·0
Hind foot	46–51	44–52	48	48	1·9	2·4
Ear	27–31·5	26–32	29	29	1·6	1·7

Dactylopsila tatei sp. n.

Type locality: Mts. above Taibutu village, Faralulu district, West Fergusson Island, SE. New Guinea, 2,000–3,000 ft.

Type: Adult ♀ 50.1327, collector's No. 433, 30 July 1935. Skin and skull.

Paratypes: ♀ 50.1325, collector's No. 421, 1326, collector's No. 423, 1329, collector's No. 435, juv. 1328, collector's No. 434 (of 1327), 1331, collector's No. 438 (skull and piece of skin), ♂ 1323, collector's No. 425, 1324, collector's No. 431, 1330, collector's No. 439 (skull and piece of skin), Mts. above Taibutu village, Faralulu district, West Fergusson Island, SE. New Guinea, 2,000–3,000 ft.

These nine specimens of *Dactylopsila* taken in West Fergusson Island are most nearly allied to *D. t. trivirgata*. The black and white markings on the head and back are very similar, the median stripe being a little darker than the two lateral ones. The hairs on the backs of the fore and hind feet are whitish. They are at once distinguished from *trivirgata* by the absence of the large black chin spot and by the shorter tail which, on the upper side, has only a few or no grey hairs near the base. On the underside the transition from grey to black takes place at about 70–80 mm. from the base. The tip of the tail is white.

The skull is very similar to that of *trivirgata* but is smaller.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	*Breadth mesopterygoid fossa*	*Width inside of m^1–m^1*	p^4–m^4	$m^{1\text{-}3}$
50.1327 Type	♀	213	274	45	24	48·6	35·5	7·3	17·8×7·8	25·0	3·0	6·2	7·0	11·7	8·2
1325	♀	200	270	44·5	24	48·4	36·0	7·2	17·9×8·2	24·9	2·4	6·5	6·7	11·6	8·1
1326	♀	195	267	43	22·5	47·3	35·9	7·5	17·8×7·5	25·2	2·2	7·0	7·2	11·8	8·4
1329	♀	195	273	43	24	46·7	34·0	7·6	16·1×6·8	25·0	2·5	6·2	6·6	11·4	8·1
1328	♀*	130	179	33·5	20	35·0	25·0	6·3	13·7×6·3	—	2·2	—	—	—	—
1331	♀	183	262	42	23	44·8	31·8	6·8	16·0×6·0	23·9	2·9	6·5	6·7	11·7	8·4
1323	♂	181	283	46	22	46·0	33·9	7·2	17·0×6·7	24·5	2·4	6·6	7·0	12·0	8·5
1324	♂	173	265	43·5	22	43·6	32·2	7·2	15·8×5·7	23·1	2·7	6·6	6·6	11·4	8·1
1330	♂	210	286	46	24	48·8	36·4	8·0	17·7×7·2	26·0	3·3	7·0	7·3	11·6	8·0

* juvenile

Dactylonax palpator (Milne-Edwards)

Dactylopsila palpator Milne-Edwards, 1888, *Mem. Soc. Philom. Centenaire, Paris*: 173–177.
Type locality: Aroa River, Papua.
Dactylopsila palpator ernstmayri Stein, 1932, *Z. Säugetierk.* **7**: 254.
Type locality: Junzaing, Saruwaged Range, Huon Peninsula, New Guinea.
Dactylonax palpator (Milne-Edwards), Tate, 1945, *Amer. Mus. Novit.*, No. 1305:5.

Twenty-two specimens. Four from eastern Papua: juv. ♂ 50.1032, ♀ 1037, juv. ♀ 1033, Boneno, Mt. Mura; young ad. ♀ 102, Enaena, NE. slopes Mt. Simpson; and eighteen from NE. New Guinea: ♂ 1015, Baiyanka, SE. Bismarck Range; ♂ 1332, Kuraka, Kratke Mts.; ♂ 1336–1340, ♀ 1341–1345, Bubu River district; ♀ 1333–1335 (one young in pouch, collectors No. 486*a*), Saiko, Bubu River; ♂ 1823, juv. ♂ 1824, Yanka, eastern slopes Hagen Range; ♀ 1825, Tomba, SW. slopes Hagen Range.

In this excellent series there are five specimens which have a well-developed white ring of hair round their wrists (Nos. 1337, 1342, 1037, 1336, and 1033) which is the only distinctive character given by Stein (1932) for the race *ernstmayri* which Tate (1945) suggests is synonymous with *palpator*; this certainly appears to be the case in this series. It is noticeable that the males grow to a larger size than the females.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	p^4–m^4	m^{1-3}
50·1015	♂	255	235	49	28	57	46·2	9·4	22·5×8·4	13·6	9·3
1340	♂	240	236	47	30	—	—	—	—	—	—
1332	♂	239	227	50	27	57·9	46·6	9·2	22·5×7·7	12·9	8·6
1338	♂	238	212	48	29	—	—	—	—	—	—
1337	♂	232	213	45·5	28	54·0	43·7	9·2	19·9×6·8	12·5	8·6
1336	♂	232	230	47	29	—	—	—	—	—	—
1032	♂	220	212	47	29	54·8	41·3	8·6	20·2×5·7	13·5	9·2
1037	♀	235	205	50	30	55·8	44·4	8·9	21·0×6·9	13·4	9·0
1343	♀	224	201	45·5	27·5	—	—	—	—	—	—
1345	♀	222	215	46	30	—	—	—	—	—	—
1334	♀	211	200	45	28	53·7	41·6	8·9	20·1×6·4	12·7	8·8
1344	♀	208	194	43·5	27	—	—	—	—	—	—
1342	♀	208	207	43	25	51·7	43·9	8·5	18·8×6·9	12·5	8·5
1335	♀	208	203	45	26	50·0	43·5	9·5	19·6×6·2	12·3	8·3
1341	♀	204	216	48	27·5	—	—	—	—	—	—
1333	♀	207	198	42·5	27	50·6	42·4	9·2	21·5×6·8	12·0	8·2
1823	♂	235	212	46	26·5	52·0	44·8	9·4	21·0×8·2	13·0	8·9
1825	♀	196	200	44	25·5	45·5	38·3	8·4	17·9×6·8	13·0	9·0

Petaurus breviceps papuanus Thomas

Petaurus breviceps var. *papuanus* Thomas, 1888, *Catalogue of the Marsupialia and Monotremata in the British Museum*: 158.

Type locality: Huon Gulf, eastern New Guinea.

Petaurus (*Petaurella*) *papuanus papuanus* Tate & Archbold, 1937, *Bull. Amer. Mus. Nat. Hist.* **73:** 387.

Petaurus breviceps papuanus Thomas, Tate, 1945, *Amer. Mus. Novit.*, No. 1305:9.

Five specimens. Three, ♂ 50.1377, 1378, ♀ 1379, from Taibutu, Faralulu district West Fergusson Island, SE. New Guinea; and two from NE. New Guinea: ♂ 1380, Garaina, Upper Waria River; ♀ 1826 (white-tipped tail), Degabaga, 8 miles east Hagen Range, Sepik-Waghi Divide.

Petaurus breviceps tafa Tate & Archbold

Petaurus (*Petaurella*) *papuanus tafa* Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 810: 1; 1937, *Bull. Amer. Mus. Nat. Hist.* **73:** 387.

Type locality: Mt. Tafa, Central Division of Papua.

Petaurus breviceps tafa Thomas, Tate, 1945, *Amer. Mus. Novit.*, No. 1305:10.

Ten specimens. Seven from NE. New Guinea: ♂ 50.1382, 1381, ♀ 1383, Kambaidam, Kratke Mts.; ♂ 1385, 1384, ♀ 1386, Saiko, Bubu River; ♂ 1069, Baiyanka, SE. Bismarck Range; and three from eastern Papua; ♂ 1070, Enaena, NE. slopes Mt. Simpson; ♂ 1071, ♀ 1072, Boneno, Mt. Mura.

These highland specimens are new to our collection. They were taken between 4,000 and 7,500 ft. and agree with Tate & Archbold's description of the dark-coloured mountain race *tafa* (especially when comparing teeth measurements),

though the pelage on the back is only 9–10 mm. long as compared with 12 mm. in the type. They are smaller than typical *papuanus*, grey ventrally with only a slight buffy overwash. Three of them, ♂ 1382, ♀ 1386 and ♀ 1072, have a patch of buffy hairs in the middle of the belly, and ♂ 1069 has a white tip to its tail.

Measurements of four specimens which range from the smallest to the largest are given.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Beadth braincase*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	p^4–m^4	m^{1-3}	p^4	m^1	m^2
50.1072	♀	123	154	22	23	27·6	22·4	6·7	16·2	10·7×5·0	16·3	1·8	6·6	4·5	1·0	1·9×1·8	1·5×1·5
1381	♂	128	178	23	22·5	31·0	23·3	7·1	15·7	13·4×5·8	17·7	1·9	7·2	4·7	1·4	2·0×1·8	1·6×1·7
1382	♂	133	160	22·5	22	30·9	24·2	7·0	16·0	12·9×5·3	17·7	1·9	7·3	4·8	1·3	1·9×1·8	1·6×1·7
1385	♂	137	174	24	23·5	30·9	23·0	7·2	16·2	13·4×5·8	17·9	1·9	7·1	4·7	1·4	1·8×1·7	1·5×1·6

Pseudocheirus* (*Pseudochirops*) *cupreus cupreus Thomas

Pseudochirus cupreus Thomas, 1897, *Ann. Mus. Stor. nat. Genova*, **38:** 145–146.
Type locality: Mount Owen Stanley, British New Guinea.
Pseudochirus (*Pseudochirops*) *cupreus obscurior* Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 810: 3–4.
Pseudocheirus (*Pseudochirops*) *cupreus cupreus* Thomas, Tate, 1945, *Amer. Mus, Novit.*, No. 1287: 20–21.

Seventeen specimens, all from NE. New Guinea: ♂ 50.1369, 1370, 1372, juv. ♂ 1368, juv. ♂ 1371, Saiko, Bubu River; ♀ 1373, 1374, 1375, Bubu River district; ♂ 1367, Sasara, Kratke Mts.; ♂ 1066, juv. ♂ 1067, ♀ 1068, Baiyanka, SE. Bismarck Range; ♂ 1063, juv. ♂ 1062, ♀ 1065, juv. ♀ 1064, Tapu, Upper Ramu River Plateau; ♀ 1818, Yanka, eastern slopes Hagen Range.

The pelage of these specimens does not differ markedly from that of the adult type specimen, but the immature specimens are much darker.

They extend the range of this species to the north-west as far as the Upper Ramu River Plateau.

Pseudocheirus mayeri Rothschild & Dollman

Pseudochirus mayeri Rothschild & Dollman, 1932 (November) Abstr., *Proc. Zool. Soc. Lond.* No. 353:15.
Type locality: The Gebroeders, Weyland Mts., Dutch New Guinea.
Pseudochirulus pygmaeus Stein, 1932 (December), *Z. Säugetierk.* **7:** 257.
Type locality: Sumuriberg, Weyland Mts., Dutch New Guinea.

One specimen, ♂ 50.1808, Tomba, SW. slopes Hagen Range, NE. New Guinea.

This species is found high up in the mountains between 6,000 and 12,000 ft. It appears that this is the first record of its occurrence outside Dutch New Guinea and so extends its known range into eastern New Guinea. The pelage is dense, and very soft, the upper parts greyish brown and the underparts buff with the bases of the hairs grey. The hands and feet are a light brownish buff and there is a whitish patch

of hairs at the base of the ears. The measurements of this specimen agree very closely with those for *mayeri* (*pygmaeus*) given by Tate (1945).

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	p^4	p^4–m^4	m^{1-3}	m^1	m^4
50·1808	♂	194	176	25	20	42·2	24·2	13·5 × 6·0	2·1 × 1·5	11·7	7·5	2·7 × 2·1	2·2 × 1·8

Pseudocheirus forbesi forbesi Thomas

Pseudochirus forbesi Thomas, 1887, *Ann. Mag. Nat. Hist.* **19:** 146.
Type locality: Sogere, Astrolabe Range, SE. New Guinea, 2,000 ft.
Pseudocheirus forbesi forbesi Thomas, Tate, 1945, *Amer. Mus. Novit.*, No. 1287:11.

Five specimens all from eastern Papua: ♂ 50.1039, 1040, juv. ♂ 1042, ♀ 1041, Enaena, NE. slope Mt. Simpson; ♀ 1038, Boneno, Mt. Mura.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	p^4–m^4	m^{1-3}
50.1039	♂	250	238	36	20	49·8	29·2	17·8 × 7·0	14·2	8·9
1040	♂	277	271	37	19	52·7	29·9	— × 7·8	14·1	9·2
1041	♀	227	238	33	19	45·7	27·2	16·1 × 6·7	13·5	8·8
1038	♀	230	255	33	20	47·4	28·0	— × 6·6	13·8	8·8

Pseudocheirus forbesi larvatus (Fôrster & Rothschild)

Phalanger larvatus Fôrster & Rothschild, 1911, *Ann. Mag. Nat. Hist.* **7:** 1337.
Type locality: Rawlinson Mountains, Huon Peninsula, New Guinea.
Pseudochirulus capistratus Matschei, 1915, *S.B. Ges. naturf. Fr. Berl.* **1915:** 92.
Type locality: Schrader Mts. between the Sepik and Ramu Rivers, NE. New Guinea.
Pseudochirulus barbatus Matschie, 1915, ibid.: 93.
Type locality: Sattelburg, north of Huon Gulf, NE. New Guinea.
Pseudocheirus forbesi larvatus (Fôrster & Rothschild), Tate, 1945, *Amer. Mus. Novit.*, No. 1287:12.

Fourteen specimens all from NE. New Guinea: ♂ 50.1346, juv. ♂ 1347, ? sex 1348 and 1349 (skulls only), Kambaidam, Kratke Mts.; ♂ 1350, Buntibasa, Kratke Mts.; ♀ 1351, Kuraka, Kratke Mts.; ♂ 1043, ♀ 1044, Tapu, Upper Ramu River Plateau; ♂ 1045, Baiyanka, SE. Bismarck Range; ♂ 1354, 1352, 1353, 1355, Saiko, Bubu River; ♂ 1809, Yanka, eastern slopes Hagen Range.

There is a great similarity between the general colouring of these specimens and

P. f. forbesi, but they are larger (see measurements) and usually have much darker tails.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	$p^4–m^4$	m^{1-3}
50.1346	♂	295	300	39	20	58·9	35·7	21·0×8·4	15·3	10·2
1348	?	—	—	—	—	54·9	31·3	— 7·3	15·9	10·4
1349	?	—	—	—	—	53·2	29·7	— 6·8	15·0	9·9
1350	♂	—	—	39	20	56·0	30·6	20·4×6·8	15·9	10·5
1351	♀	270	285	38	19	57·2	31·1	20·9×7·5	15·5	10·0
1043	♂	292	280	35	20	58·8	34·7	20·8×7·0	15·1	9·8
1044	♀	236	250	31	19	50·6	28·5	— 6·5	14·7	9·9
1045	♂	298	310	40	20	59·0	32·8	— 7·5	16·2	10·9
1354	♂	286	302	42	23·5	56·4	32·1	21·4×8·1	15·4	10·1
1352	♂	260	270	38	21·5	52·1	29·2	18·2×7·0	14·8	9·9
1353	♂	298	319	41	23·5	56·7	32·7	19·8×8·8	15·2	9·9
1355	♂	323	307	39	23	61·7	34·6	22·0×9·8	15·0	9·5
1809	♂	251	268	40	19	52·7	30·7	18·9×7·6	15·6	10·6

Pseudocheirus canescens gyrator Thomas

Pseudochirus canescens gyrator Thomas, 1904, *Ann. Mag. Nat. Hist.* **14:** 401.

Type locality, Lindum Creek, Gira River district, NE. of the Central Range, Dutch New Guinea, 600 ft.

Pseudocheirus canescens gyrator Thomas, Tate, 1945, *Amer. Mus. Novit.*, No. 1287: 14–15.

Four specimens all from eastern Papua: ♂ 50.1046, ♀ 1048, 1047, Enaena, NE. slopes Mt. Simpson; ♀ 1049, Ikara, NE. slopes Mt. Simpson.

These four specimens from eastern Papua are very similar to the type specimen, which up to now appears to have been unique. The general colour is brownish-grey (two specimens, Nos. 1046 and 1047, are rather greyer than the others); the head, face, cheeks, fore and hind limbs are pale brown; and there is a well-marked fuscous frontal stripe and a darker line down the middle of the back. The ears are fuscous and have dark hairs round their bases. Ventrally the hairs are brownish-buff, their bases sometimes grey.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Mastoidal breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	$p^4–m^4$	m^{1-3}
50.1047	♀	201	173	29	17	44·7	26·7	21·8	15·8×5·7	22·8	3·9	12·5	8·0
1046	♂	225	192	33	18	46·9	27·5	22·6	15·9×6·7	23·7	4·3	12·3	7·8
1049	♀	230	200	28	16·5	47·3	27·5	22·1	17·8×6·0	24·5	4·3	12·2	7·8
1048	♀	234	182	28	17	47·3	28·0	23·4	16·9×6·8	24·4	4·7	11·7	7·7

Pseudocheirus* (*Pseudochirops*) *corinnae corinnae Thomas

Pseudochirus corinnae Thomas, 1897, *Ann. Mus. Stor. nat. Genova*, **38:** 142–144.
Type locality: Mountains of Vanapa River district, British New Guinea.
Pseudocheirus (*Pseudochirops*) *corinnae corinnae* Thomas, Tate, 1945, *Amer. Mus. Novit.*, No. 1287: 20.

Fourteen specimens all from NE. New Guinea: ♂ 50.1050, ♀ 1051, Baiyanka, SE. Bismarck Range; ♂ 1052, Tapu, Upper Ramu River Plateau; ♂ 1358, 1359, 1360, ♀ 1361, Buntibasa district, Kratke Mts.; ♀ 1356, 1357, Kuraka, Kratke Mts.; ♂ 1362, ♀ 1363, 1364, 1365, Saiko, Bubu River district; ♀ 1366, Bubu River district.

These specimens closely resemble the co-type and other specimens of *corinnae* in this Museum except for No. 1361, an adult female in which the dorsal pelage resembles that of *P. c. argenteus*. It is a bright rusty colour especially on the rump and tail, but ventrally is just the same colour as *corinnae*, a light dirty yellowish-grey.

These specimens extend the range of the species to the north-west as far as the Upper Ramu River Plateau.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	p^4–m^4	m^{1-3}
50.1052	♂	340	294	42	24	61·7	39·7	21·0×9·9	36·3	4·9	19·8	13·0
1050	♂	318	288	49	22	57·2	36·1	21·2×8·6	33·8	4·4	20·0	13·6
1051	♀	300	315	47	23	56·6	37·2	20·3×9·0	32·7	5·6	20·7	12·9
1356	♀	325	315	44	23	60·1	37·8	21·5×9·0	35·3	5·0	20·8	13·8
1358	♂	340	345	50	25	63·2	42·3	22·0×11·0	36·7	5·1	20·5	13·3
1357	♀	317	305	47	22·5	59·4	37·5	—	35·2	5·2	20·0	13·2
1363	♀	340	335	51	24	62·3	40·0	20·0×9·8	36·4	6·2	19·5	12·8
1364	♀	350	320	47·5	25	62·4	40·0	22·2×10·6	36·6	5·6	19·6	12·7
1365	♀	315	315	46·5	25	—	38·4	*c.* 20·0×9·2	—	5·4	20·2	13·4
1362	♂	325	305	48	24	62·1	40·3	21·7×9·7	36·9	5·0	20·7	13·7
1366	♀	345	323	47·5	26	61·4	39·0	21·0×10·8	36·4	5·4	19·8	12·8

Pseudocheirus* (*Pseudochirops*) *corinnae fuscus subsp. n.

Type locality: Ikara, NE. slopes Mt. Simpson, eastern Papua, SE. New Guinea, ±4,000 ft.

Type: Adult ♀ 50.1058, collector's No. 761, 16 August 1940. Skin and skull.

Paratypes: ♂ 50.1054, collector's No. 763, 1055, collector's No. 764, young ad. 1053, collector's No. 762, ♀ 1057, collector's No. 757, young ad. 1056, collector's No. 753, Ikara, NE. slopes Mt. Simpson, eastern Papua, ±4,000 ft.; ♀ 1059, collector's No. 774, 1060, collector's No. 785, Enaena, NE. slopes Mt. Simpson, eastern Papua, ± 5,000 ft.; ♀ 1061, collector's No. 945, Boneno, nr. Mt. Mura, eastern Papua, 4,000–5,000 ft.

Rather darker than typical *corinnae*. Most of the hairs are a dark greyish-brown

tipped with silver, buffy, rust, or black. The black median dorsal stripe is well defined and there is an indistinct dark brown stripe along each side of the back. There is a patch of white or yellowish-white hairs at the base of the ears.

This race can be at once distinguished from typical *corinnae* by the very distinct, usually diamond-shaped patch of white hairs on the throat and chest. The rest of the ventral surface is a rather dark yellowish-grey or yellowish-brown.

The general appearance and the measurements of the skull are very similar to those of typical *corinnae*; one of the main differences, however, is in the length of p^4–m^4 and m^{1-3}. Both are usually longer, the greatest lengths recorded for specimens in this collection being p^4–m^4 = 21·8 with m^{1-3} = 14·3, compared with maximum lengths for typical *corinnae* of p^4–m^4 = 20·8 with m^{1-3} = 13·8 (see table). The frontals are often more depressed than those of typical *corinnae*, the supra-orbital ridges are well developed, and in adult specimens there is a well-developed sagittal crest.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	p^4–m^4	m^{1-3}
50.1056	♀	333	329	47	25	62·0	38·0	22·0×9·8	36·4	5·9	21·5	13·8
1057	♀	330	350	51	25	62·8	39·8	20·5×9·8	37·0	5·4	21·3	14·4
1058 Type	♀	352	310	49	25	61·4	39·1	21·8×10·1	35·5	5·8	20·5	13·4
1053	♂	334	326	—	27	61·0	40·0	19·7×10·6	36·7	5·2	21·4	13·9
1054	♂	337	345	50	27	64·0	42·8	22·9×10·8	37·6	5·4	21·8	14·3
1055	♂	354	371	51	27	65·2	44·7	22·1×11·5	38·3	5·7	21·4	13·7
1059	♀	326	335	50	25	58·8	37·6	— ×8·7	35·0	5·4	21·5	14·6
1060	♀	319	315	49	28	58·7	38·2	21·0×10·5	34·8	4·8	21·5	13·8
1061	♀	339	354	50	26	62·4	40·5	21·2×10·0	36·9	5·4	20·9	13·7

Phalanger orientalis orientalis (Pallas)

Didelphis orientalis Pallas, 1766, *Miscellanea Zoologica*: 59–62.
Type locality: Amboina, off SW. coast of Ceram.
?*Phalangista quoy* Gaimard, 1824, *Bull. Sci. Nat. Paris*, **1**: 271.
Quoy & Gaimard, *Voyage. . . . Uranie et Physicienne*. Zoologie: 58, t.l. Waigeu.
?*Coescoes amboinensis* Lacépède, 1801, *Mém. Inst. Paris*, **3**: 491, t.l. Amboina.
Phalanger o. orientalis (Pallas), Tate, 1945, *Amer. Mus. Novit.*, No. 1283: 1–31.

Three specimens, ♂ 50.1285, 1286, juv. 1287 (skull and piece of skin) from the Faralulu district, West Fergusson Island, SE. New Guinea.

These specimens are very similar to others in the British Museum's collection. The general colour is white, tinged, especially on the throat and sides of the neck, with yellow. The dorsal surface is covered with longer black-brown hairs which are most numerous on the head and neck, on all four feet and base of tail, and, of course, along the dorsal line, which is well defined.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Mastoidal breadth*	*Nasals*	p^4–m^4	m^{1-3}	p^4	m^1
50.1285	♂	389	362	60	25·5	75·5	50·9	40·0	29·3×12·8	22·2	13·6	4·7	4·6×3·8
1286	♂	397	340	—	—	76·1	57·5	42·7	34·8×14·6	22·8	15·0	4·4	5·0×4·0

Phalanger vestitus (Milne-Edwards)

Cuscus vestitus Milne-Edwards, 1877, *C.R. Acad. Sci. Paris*, **85:** 1080.
Type locality: Karons Mountains, Tamrau Mountains, northern Vogelkop.
Phalanger carmelitae Thomas, 1898, *Ann. Mus. Stor. nat. Genova*, **39:** 5.
Type locality: Upper Vanapa River, British New Guinea.
Phalanger sericeus Thomas, 1907, *Ann. Mag. Nat. Hist.* **20:** 74.
Type locality: Owgarra, Angabunga River, SE. New Guinea.
Phalanger coccygis Thomas, 1922, *Ann. Mag. Nat. Hist.* **9:** 673.
Type locality: Surawaged Mts., Huon Peninsula, New Guinea.
Phalanger vestitus (Milne-Edwards), Tate, 1945, *Amer. Mus. Novit.*, No. 1283: 16.

Forty-six specimens. Thirty-two from NE. New Guinea: ♂ 50.1269, 1270, ♀ 1271, 1272, 1273, juv. ♀ 1274, Sasara, Kratke Mts.; ♀ 1275, juv. ♀ 1276, Buntibasa district, Kratke Mts.; ♂ 1277, 1278, 1279, ♀ 1280, juv. ♀ 1281, Saiko, Bubu River; ♂ 1262, 1263, 1264, 1265, ♀ 1266, 1267, 1268, 1284, Bubu River district; juv. ♀ 1283, Arau, Kratke Mts.; ♂ 992, 996, duplicate—collector's No. 735 (skull only), ♀ 997, juv. ♀ 1000, juv. ♂ 998, juv. ♂ 999, Baiyanka, Bismarck Range; ♂ 993, ♀ 994, juv. ♀ 995, Tapu, Upper Ramu River Plateau; ♂ 1817, Yanka, eastern slopes Hagen Range; and fourteen from eastern Papua; ♂ 989, 990, Mt. Mura; ♂ 991, 1002, ♀ 1004, juv. ♀ 1003, Boneno, Mt. Mura; ♀ 1001, Bibitau, Mt. Orian; ♀ 1005, juv. ♀♀ 1009 (young of 1005), 1008, 1006, 1010, juv. ♂ 1007, Enaena, NE. slopes Mt. Simpson.

This excellent collection of skins which includes those of fourteen juvenile specimens indicates the great variability in the colour and length of hair in this species, from a short-haired pale silvery-brown specimen (adult ♀ 1004) through intermediate forms which are nearer the type specimen of *carmelitae* Thomas (1898) to a dark brown longer-haired specimen (adult ♀ 994) which is very similar to the type of *sericeus* Thomas (1907). The type of *coccygis* Thomas (1922) also fits into this series, supporting the view suggested by Tate (1945) that *carmelitae*, *sericeus*, and *coccygis* are synonymous. There is also a great similarity in appearance between the juvenile forms and a specimen of *P. vestitus* which we have in this Museum and which I am unable to distinguish from the young specimens in the Shaw Mayer collection. The pelage of these specimens is usually longer than that of the adults, and is a little darker and somewhat grizzled, especially along the sides of the body; and the dark brown mid-dorsal line is more clearly defined.

The type of *vestitus* (*Cuscus vestitus* Milne-Edwards), which I have not seen, is a young specimen and the description of it agrees with that of the young specimens

in this collection. It appears, therefore, that *carmelitae*, *sericeus*, and *coccygis* are synonymous with *vestitus* and not races of it as suggested by Tate (1945).

The hair on the backs of specimens 1273 and 1284 is very short as it has been clawed off by the young.

The following are the measurements in millimetres of seventeen adult males and fourteen adult females of *vestitus*:

	Extremes		*Average*		*Standard deviation*	
	♂	♀	♂	♀	♂	♀
Head and body	327–437	353–455	408	407	28·1	29·3
Tail	305–404	333–387	356	367	26·3	15·2
Hind foot	56–66	57–62	60	60	3·9	2·0
Ear	19–27	20–26	23	24	2·1	2·1
Basal length	68·3–78·8	68·8–78·4	74·4	73·1	3·3	2·9
Zygomatic breadth	47·0–56·9	45·4–52·3	51·1	48·9	2·6	1·8
Mastoidal breadth	37·4–45·3	37·0–46·4	41·8	41·0	2·4	2·5
Nasals, length	26·3–31·9	25·6–31·3	29·0	27·7	1·9	1·9
Nasals, breadth	10·0–14·5	10·1–13·1	12·3	11·9	1·1	0·9
p^4–m^4	23·7–26·8	23·7–26·7	25·2	25·0	0·9	0·9
m^{1-3}	15·7–17·7	15·2–17·9	16·6	16·3	0·5	0·7

Measurements in mm. of twelve juvenile specimens (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Mastoidal breadth*	*Nasals*
50.1274	♀	275	270	46	20	53·5	36·8	29·7	23·1 × 10·8
1276	♀	325	295	53	21	60·7	40·0	32·6	24·2 × 10·1
1281	♀	315	300	49	23	59·1	39·1	31·0	20·0 × 11·5
1283	♀	280	300	51	20	54·9	38·0	31·5	22·9 × 10·0
1008	♀	328	342	54	24	60·6	38·5	31·1	21·7 × 11·1
1006	♀	355	323	—	—	63·4	42·0	34·1	25·0 × 10·5
1010	♀	341	341	57	26	64·7	40·5	33·2	25·0 × 10·3
1007	♂	406	392	63	27	73·4	48·0	38·8	26·0 × 12·0
998	♂	343	340	57	23	64·3	42·2	36·2	— × 11·7
999	♂	364	323	59	24·5	67·0	43·2	36·8	24·5 × 11·4
995	♀	338	335	52	21	60·7	40·5	33·6	22·0 × 10·9
1003	♀	376	344	57	25	66·9	42·0	33·7	25·0 × 12·2

Phalanger gymnotis (Peters & Doria)

Phalangista gymnotis Peters & Doria, 1875, *Ann. Mus. Stor. nat. Genova,* **37:** 543
Type locality: Aru Islands.
Phalanger leucippus Thomas, 1898, ibid. **39:** 7–8.
Type locality: Upper Vanapa River, British New Guinea.
Phalanger gymnotis (Peters & Doria), Tate, 1942, *Amer. Mus. Novit.,* No. 1283: 1–31.

Ten specimens. Seven from NE. New Guinea: juv. ♂ 50.1261, Saiko, Bubu River; ♂ 1258, juv. ♂ 1259, juv. ♀ 1260, Bubu River district; ad. ♂ 1257, Kambaidam,

Kratke Mts.; ad. ♀ 984, 985, Baiyanka, SE. Bismarck Range; and three from Eastern Papua: juv. ♀ 986, Enaena, NE. slopes Mt. Simpson; ♂ 988 (Boneno Camp), Mt. Maneao; ♂ 987, Mt. Mura.

These specimens extend the range of this species to the north and south of its previously recorded range, from the Bismarck Range, NE. New Guinea, to Mt. Simpson in the south of eastern Papua.

The skins show little variation in colour from the type of *leucippus* (= *gymnotis*) in the British Museum's collection; the younger specimens are darker, and have a more pronounced median dorsal stripe, than the adult specimens.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Mastoidal breadth*	*Nasals*	p^4–m^4	m^{1-3}
50.984	♀	415	318	64	27	70·3	48·9	41·2	39·8 × 11·9	—	—
985	♀	400	310	—	29	67·8	45·0	39·0	28·8 × 10·9	—	—
988	♂	472	355	65	30	80·5	58·5	49·1	34·4 × 12·9	25·6	15·7
987	♂	470	330	69	30	79·9	60·1	47·6	33·7 × 12·6	25·5	15·5
1258	♂	440	320	63	28	78·4	54·4	48·1	34·1 × 13·6	24·0	14·6
1257	♂	465	350	66	30	83·1	60·1	50·0	34·2 × 15·0	24·8	15·0

Echymipera oriomo Tate & Archbold

Echymipera oriomo Tate & Archbold, 1936, *Amer. Mus. Novit.*, No. 823:1.
Type locality: Dogwa, Oriomo River, Western Division of Papua.

One specimen ♀ 50.1139, from Tapu, Upper Ramu River Plateau, NE. New Guinea.

One fully adult (old) specimen, judging from the skull of a species which is new to our collection. The teeth are very worn down both in the upper and lower jaws, and many of them are missing. The tail has been broken off at the root. Miklouho-Maclay (1884) mentions that specimens of bandicoots sometimes have the tail lost (or bitten off?).

It is a small-sized species with spinous pelage and relatively small-sized teeth. The colour of the pelage agrees with that described for *oriomo* Tate (1936), and though many of the measurements of this specimen are larger than those of the type this may be due to differences in age, which may also account for the difference in the size of the posterior palatal openings and those of the type *oriomo*. In the type these extend from the front of m^1 to the back of m^2, whereas in this specimen they extend from the front of m^1 to between m^3 and m^4. Differences in the breadth of the teeth (they are wider in our specimen) may be due to wear.

Measurements in mm. (taken in the flesh; measurements of type in parentheses): Head and body 291 (244); tail—broken off; hind foot 48 (47); ear 23·5; skull, basal length 57·3 (52·3); zygomatic breadth 25·9 (24·0); nasals 26·9 × 5·0 (damaged) (24·3 × 4·8); palatal length 38·6 (35·2); anterior palatal foramina 6·0; posterior palatal foramina 8·4 (from front of m^1 to between m^3 and m^4); teeth (crowns) m^{1-3}

9·9 (10·5); m^{1-2} *c.* 6·2; m^1 (length × breadth) 3·0 × 3·0; m^2 missing; m^3 3·5 × 4·0; m^{1-2} (to front of m^3) 6·5.

Echymipera doreyana doreyana (Quoy & Gaimard)

Perameles doreyana Quoy & Gaimard, 1830, *Voyage de la corvette l'Astrolabe, Zool.* 1:100.
Type locality: Dorey (nr. Manokwari), Dutch New Guinea.
Perameles cockerelli Ramsay, 1877, *Proc. Linn. Soc. N.S.W.* **1**: 310, 378.
Type locality: New Ireland.
Perameles myoides Gunther, 1883, *Ann. Mag. Nat. Hist.* **11**: 247.
Type locality: New Britain.
Brachymelis garagassi Miklouho-Maclay, 1884, *Proc. Linn. Soc. N.S.W.* **9**: 713.
Type locality: Maclay Coast (Cape Croisilles to Cape King William), NE. New Guinea.
Anuromeles rufiventris Heller, 1897, *Abh. zool. anthrop. ethn Mus. Dresden,* **6**: 5.
Type locality: Bongu, Astrolabe Gulf, New Guinea.
Suillomeles hispida Allen & Barbour, 1909, *Proc. New England zool. Cl.* **4**: 44.
Type locality: Manokwari, Dore Bay, Dutch New Guinea.
Perameles doreyana and *breviceps* Cohn, 1910, *Zool. Anz.* **35**: 724.
Echymipera doreyana doreyana (Quoy & Gaimard) Tate, 1948, *Bull. Amer. Mus. Nat. Hist.* **92**: 332–333.

Two specimens: ♀ 50.1420, Taibutu, Faralulu district, West Fergusson Island, SE. New Guinea; and ♂ 138, Wapona, north slope Maneao Range, eastern Papua.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4–m^4	m^{1-3}	m^{1-2}	m^1	m^2	m^3
50.1420	♀	321	99	55·5	27	62·6	25·9	34·6×4·6	41·0	4·9	6·0	15·6	11·0	7·3	3·9×2·6	3·5×2·9	3·9×3·4
1138	♂	342	84	65	32	69·0	27·3	34·7×6·6	45·7	8·7	6·7	18·1	12·4	8·1	4·4×2·6	4·0×3·2	4·4×4·0

Peroryctes raffrayanus raffrayanus (Milne-Edwards)

Perameles raffrayanus Milne-Edwards, 1878, *Ann. Sci. Nat. Zool.* **7**: Art. 11: 1–2.
Type locality: Amberbaki, Vogelkop, Dutch New Guinea.
Peroryctes raffrayanus raffrayanus (Milne-Edwards), Tate, 1948, *Bull. Amer. Mus. Nat. Hist.* **92**: 327.

Five specimens. Four specimens from NE. New Guinea, ♂ 50.1407, Kuraka, Kratke Mts.; ♀ 1411, Sasara, Kratke Mts.; juv. ♀ 1408, ♂ 1410 (skull and piece of skin), Kambaidam, Kratke Mts.; and one juv. ♀ 1137, from Enaena, NE. slopes Mt. Simpson, eastern Papua.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4–m^4	m^{1-3}	m^{1-2}	m^1	m^2	m^3
50.1407	♂	358	197	80	32	77·4	31·1	38·6×6·3	49·7	9·8	11·1	17·2	12·0	8·2	4·3×2·7	3·8×3·1	3·9×3·4
1411	♀	333	174	72	31·5	72·1	30·1	34·9×5·0	47·0	7·5	9·7	16·2	11·5	7·9	4·0×2·7	3·8×3·0	3·7×3·4

Peroryctes longicauda ornata (Thomas)

Perameles ornata Thomas, 1903, *Proc. Zool. Soc. Lond.* **2:** 201.
Type locality: Avera, Aroa River, British New Guinea.
Peroryctes longicauda ornatus (Thomas), Tate, 1948, *Bull. Amer. Mus. Nat. Hist.* **92:** 329.

Fourteen specimens all from NE. New Guinea: ♂ 50.1121, 1122, ♀ 1123, Tapu, Upper Ramu River Plateau; ♂ 1124, Baiyanka, SE. Bismarck Range; ♂ 1414, 1418, ♀ 1415, 1416, 1417, Kuraka, Kratke Mts. and Kambaidam, Kratke Mts.; ♂ 1312, ♀ 1413, Saiko, Bubu River; ♂ 1840, 1841, Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide; ♀ 1842, Menebe, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

These specimens agree closely with the type except that the five specimens from the Kratke Mts. are more rufous, especially ventrally.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4–m^4	m^{1-3}	m^{1-3}
50.1121	♂	260	196	59	25	60·0	23·1	12·8	24·8 × 4·5	35·9	5·2	8·6	13·2	9·4	6·5
1122	♂	258	178	56	25·5	58·6	22·5	13·5	23·3 × 4·6	35·7	5·2	8·9	13·8	10·3	7·0
1123	♀	241	184	55	25	55·1	22·6	13·3	23·3 × 4·6	32·9	4·8	7·3	12·6	9·2	6·4
1124	♂	267	194	59	26	61·2	—	13·2	26·0 × 5·7	36·7	5·1	8·8	13·1	9·2	6·3
1414	♂	258	204	60	26	58·7	23·0	13·9	24·5 × 5·5	34·9	5·8	7·8	13·6	10·5	7·0
1418	♂	257	207	56	26	60·6	23·3	13·1	24·8 × 4·7	36·1	5·6	9·4	13·7	10·0	6·9
1415	♀	258	187	54	24	58·3	22·4	12·6	23·9 × 5·0	34·2	—	8·3	13·3	9·7	6·6
1416	♀	239	185	56	27	58·3	22·5	12·6	23·4 × 4·6	34·3	—	8·5	13·1	9·5	6·5
1417	♀	263	190	58	26	59·0	22·6	12·3	25·1 × 4·9	35·0	4·8	8·7	12·7	9·3	6·3
1412	♂	275	217	61	26·5	61·5	22·8	12·7	26·8 × 5·1	37·0	6·0	7·6	14·2	10·7	7·3
1413	♀	262	194	56	26·5	57·3	21·6	12·0	25·2 × 4·5	33·8	5·3	6·9	12·9	9·8	6·8
1840	♂	282	216	61	26·5	62·7	23·8	13·8	27·0 × 4·9	37·3	5·0	7·9	13·6	10·0	6·9
1841	♂	266	188	56	25	59·8	23·4	13·6	25·6 × 5·0	35·5	5·5	8·1	13·6	9·9	6·9
1842	♀	265	196	54	25	59·7	22·3	13·0	26·3 × 4·6	35·9	4·1	8·5	13·4	9·8	6·8

Peroryctes longicauda magna subsp. n.

Type locality: Ikara, NE. slopes Mt. Simpson, eastern Papua, SE. New Guinea. 3,500 ft.

Type: Adult ♂ 50.1126, collector's No. 768, 18 August 1940. Skin and skull.

Paratypes: ♂ 50,1125, collector's No. 751, Ikara, NE. slopes Mt. Simpson, eastern Papua, 3,500 ft.; ♀ 1128, collector's No. 830, juv. ♀ 1129, collector's No. 818, juv. ♂ 1127, collector's No. 884, Enaena, NE. slopes Mt. Simpson, eastern Papua, 4,000 ft.

The colour and marking of the skins of this series is almost identical with that of the type of *Peroryctes longicauda ornata*, but the specimens are larger and have slightly longer tails, and the undersides are a little darker buff. The general body colour is pale brown speckled with black, with a prominent black mid-dorsal line. This line begins between the eyes, broadens out on the crown and nape, and continues to the base of the tail. There is also a black streak running through each eye from the root of the whiskers to the base of the ear, and a black line on each side of the rump parallel with the median line, which passes on to the back of the hind legs. Unlike *ornata* there are very few longer hairs on the underside of the tail, but a line of longer hairs is usually present along each side.

The skull is very similar to that of *Peroryctes longicauda ornata* but is a little larger; the additional pair of anterior palatal foramina are smaller and may be minute.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4–m^4	m^{1-3}	m^{1-2}
50.1126 Type	♂	302	258	69	28	68·5	25·1	29·4×5·6	13·2	39·6	6·1	8·5	15·1	10·5	7·4
1125	♂	290	243	67	28	65·7	24·0	28·0×5·6	12·9	39·2	6·0	8·5	15·1	11·2	7·6
1128	♀	303	226	63	27	76·3	25·1	28·1×5·2	13·3	39·6	5·5	8·9	13·9	10·2	6·8
1129	♀*	226	193	53	25	51·7	19·8	21·8×4·5	11·8	31·4	5·6	—	—	—	—
1127	♂*	276	240	64	28	61·7	23·1	28·0×5·4	13·0	36·9	6·2	7·9	14·9	10·8	7·4

* juvenile

Peroryctes papuensis sp. n.

Type Locality: Boneno, Mt. Mura (30 miles NW. Mt. Simpson) Main Range, eastern Papua, SE. New Guinea, 4,000–5,000 ft.

Type: Adult ♂ 50.1130, collector's No. 816, 3 September 1940. Skin and skull.

Paratypes: ♀ 50.1135, collector's No. 982, 1136, collector's No. 994, Boneno, Mt. Mura, eastern Papua, 4,000–5,000 ft.; ♀ 1133, collector's No. 865, 1132, collector's No. 862, 1131, collector's No. 812, juv. 1134, collector's No. 813, Enaena, NE. slopes Mt. Simpson, eastern Papua, 4,000–5,000 ft.

These specimens have the same marking as *Peroryctes longicauda ornata*, but they are much smaller and the general colour of their skins is darker. There is a prominent black mid-dorsal line which begins between the eyes, broadens out on the crown and nape, and continues to the base of the tail. A black streak runs through each eye and there are two short black lines on the rump, one on each side of the middle line, which pass on to the back of the hind legs. The pelage on the underside of the body is quite a rich orange-buff except in the juvenile specimens where it is light grey. As in *P. longicauda ornata* the hairs on the underside of the tail are longer than those on the upper side.

The skulls are similar to those of *P. longicauda ornata*, but are much smaller and not so heavily built.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4–m^4	m^{1-3}	m^{1-2}
50.1130 Type	♂	198	155	45	27	48·5	17·7	20·5×4·0	11·0	29·6	4·0	7·1	10·5	7·4	5·0
1135	♀	196	150	45	28	48·0	17·6	20·4×4·0	10·7	28·0	4·6	7·7	9·8	7·2	4·7
1136	♀	175	142	43	25	43·9	16·9	18·7×3·3	10·1	26·2	4·5	6·3	10·0	7·5	4·9
1133	♀	200	155	45	26	47·4	17·2	20·4×3·2	10·6	28·2	4·2	5·6	9·7	6·8	4·7
1132	♀	193	155	44	27	47·4	17·6	19·9×3·5	10·5	28·6	4·4	5·9	10·2	7·5	4·9
1131	♀	191	143	43	26	—	17·0	19·9×3·1	10·4	27·5	4·5	6·0	9·8	6·9	4·6
1134	♀*	127	105	32	21	33·1	14·0	12·8×3·3	8·5	19·4	3·7	2·9	—	—	5·0

* juvenile

Satanellus albopunctatus (Schlegel)

Dasyurus albopuntatus Schlegel, 1880, (January) *Notes Leyden Mus.* **2:** 51–53.
Type locality: Arfak Mts., Dutch New Guinea.
Dasyurus fuscus Milne-Edwards, 1880, (June) *Ann. Mag. Nat. Hist.* **6:** 172.
Type locality: Arfak Mts.; Dutch New Guinea.
Dasyurus daemonellus Thomas, 1904, *Ann. Mag. Nat. Hist.* **14:** 402.
Type locality: Avera, Aroa River, S. coast, Papua.
Satanellus albopunctatus (Schlegel), Tate, 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 142–143.

Fourteen specimens. Thirteen from NE. New Guinea: ♂ 50.1393, ♀ 1394, juv. ♀ 1395, Buntibasa district, Kratke Mts.; ♂ 1392, Kambaidam, Kratke Mts.; ♂ 1397, 1398 (skull and piece of skin), Kuraka, Kratke Mts.; ♂ 1396, Arau, Kratke Mts.; ♂ 1399, Saiko, Bubu River; ♂ 1090, 1091, Baiyanka, SE. Bismarck Range; ♂ 1093, ♀ 1094, Tapu, Upper Ramu River Plateau; ♂ 1810, Yanka, eastern slopes Hagen Range; and one ♀ 1092 from Enaena, NE. slopes Mt. Simpson, eastern Papua.

This useful series supports the view expressed by Tate (1947) that the three forms synonymized above are alike, the seeming differences being mainly due to age.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Palatal length*	*Anterior palatal foramina*	m^{1-3}	m^{1-3}	m^4
50.1094	♀	241	221	43	29	50·2	34·1	12·9	18·6×7·8	28·5	3·5	11·8	7·7	4·3
1093	♂	231	224	46	27	48·0	30·5	11·0	18·2×7·7	27·4	3·7	12·5	8·4	5·0
1091	♂	262	244	44·5	27	54·3	37·6	13·6	21·7×9·6	30·9	3·7	11·6	7·8	4·7
1090	♂	250	247	47	29	53·7	—	12·1	22·0×8·3	31·4	4·0	12·8	8·5	5·0
1092	♀	275	280	51	27	60·5	37·0	14·1	23·0×9·7	33·8	4·4	12·5	8·4	4·8
1397	♂	271	270	45	29	—	35·1	13·5	22·7×11·1	29·9	—	11·6	7·7	3·9
1398	♂	283	259	47	30	57·8	37·7	15·2	24·7×11·2	31·3	3·6	12·3	8·3	4·7
1394	♀	255	253	46·5	29	52·3	34·7	13·6	19·9×6·7	29·8	2·9	12·3	8·2	4·7
1393	♂	283	271	50	31·9	58·0	39·5	15·5	23·9×9·8	32·7	4·2	12·4	8·3	4·7
1392	♂	279	277	50	29	59·3	38·5	15·3	25·3×11·8	32·1	3·7	12·3	8·2	4·6
1396	♂	280	264	51	31·5	59·8	40·1	13·6	22·7×8·8	32·9	3·0	12·3	8·3	4·9
1399	♂	298	290	54	29	62·8	39·7	15·0	25·7×9·5	34·9	5·0	13·5	9·0	5·2
1810	♂	269	239	46	30	55·6	—	9·9	21·0×8·1	30·0	4·4	11·5	7·5	4·9

Neophascogale lorentzi (Jentink)

Phascogale lorentzii Jentink, 1911, *Notes Leyden Mus.* **33:** 234.
Type locality: Hellwig Mts., Dutch New Guinea, 2,600 metres.
Phascogale nouhuysii Jentink, 1911, ibid. **33:** 235.
Type locality: Bivak Island, Dutch New Guinea, ± 1,050 metres.
Phascogale lorentzii venusta Thomas, 1921, *Ann. Mag. Nat. Hist.* **8:** 358.
Type locality: Weyland Mts., Dutch New Guinea, 6,000 ft.
Phascogale venusta rubrata Thomas, 1922, *Nova Guinea.... onder leiding van.... A. F. Herderschee* **13:** 739.
Type locality: Mount Goliath, central Dutch New Guinea.
Neophascogale lorentzii (Jentink), Tate, 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 136.

Three specimens from Yanka, eastern slopes Hagen Range, NE. New Guinea, ♂ 50.1804, 1805, young ad. ♀ 1806.

These are very similar to the specimens from Dutch New Guinea in this Museum, but are not so rufous.

Measurements in mm. (taken in the flesh):

Number	Sex	Head and body	Tail	Hind foot	Ear	Condylo-basal length	Zygomatic breadth	Nasals	Inter-orbital breadth	Palatal length	Anterior palatal foramina	m^{1-3}	p^4	m^1	m^2	m^3
50.1804	♂	171	188	40	23	44·3	22·5	18·3×6·3	10·5	25·4	4·2	8·4	1·0	3·0×1·9	2·7×2·6	2·7×2·9
1805	♂	200	213	42	24	51·0	26·3	23·0×7·8	10·5	28·8	4·9	8·3	1·4	2·9×2·0	2·8×2·5	2·6×2·8
1806	y. ad. ♀	184	207	39	24	47·0	23·7	19·5×6·0	10·1	26·0	4·5	8·0	—	2·7×1·9	2·7×2·5	2·6×2·9

Murexia longicaudata longicaudata (Schlegel)

Phascogale longicaudata Schlegel, 1866, *Ned. Tijdschr. Dierk., Amsterdam*, **3:** 356.
Type locality: Aru Islands.
Murexia l. longicaudata (Schlegel), Tate, 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 117.

Seven specimens all from the Kratke Mts., NE. New Guinea: ♂ 50.1400, 1401, 1402 (skull only), ♀ 1403 (skull and piece of skin), Kambaidam; ♂ 1406, Kuraka; ♂ 1405, 1404, Buntibasa district.

These specimens agree closely with the descriptions of *longicaudata* particularly when comparison is made of the measurements of the molar teeth, which in some cases are almost exactly the same as those for the type. They are new to our collection.

Measurements in mm. (taken in the flesh):

Number	Sex	Head and body	Tail	Hind foot	Ear	Condylo-basal length	Zygomatic breadth	Nasals	Inter-orbital breadth	Breadth brain-case
50.1405	♂	143	166	29	19·5	38·5	22·0	15·0×5·0	7·9	14·6
1404	♂	130	160	28·5	20	35·7	19·5	13·8×5·0	7·8	14·6
1403	♀	126	155	26·5	19	33·3	18·7	11·7×4·8	7·4	13·9
1400	♂	140	155	28	20	37·9	—	13·9×4·9	7·5	14·0
1406	♂	150	182	30	21·5	39·6	24·0	15·9×5·3	7·4	14·6
1402	—	—	—	—	—	41·0	24·0	16·0×5·9	7·4	14·6

Number	Palatal length	Anterior palatal foramina	Width mesopterygoid fossa	Width inside m^{1-1}	Outer corners of m^3	m^{1-3}	m^1	m^2	m^3	m^4
50.1405	21·7	3·5	4·4	5·8	12·0	7·6	2·7×1·9	2·6×2·3	2·2×2·7	2·0×2·6
1404	20·1	3·1	4·5	5·4	11·9	7·7	2·7×1·8	2·6×2·3	2·3×2·7	2·0×2·8
1403	18·5	3·2	4·0	5·1	11·7	7·5	2·6×1·8	2·5×2·3	2·2×2·6	1·8×2·7
1400	20·9	—	4·3	—	—	8·0	2·7×1·8	2·7×2·4	2·3×2·7	2·0×2·9
1406	22·3	3·7	4·6	6·4	13·3	7·8	2·7×1·9	2·6×2·5	2·3×2·8	2·1×2·9
1402	22·7	3·9	4·6	6·6	13·0	7·8	2·7×2·0	2·7×2·4	2·3×2·8	2·0×2·6

Murexia longicaudata parva subsp. n.

Type locality: Baiyanka, Ramu River Divide, SE. Bismarck Range, 7,500 ft.
Type: Adult ♂ 50.1114, collector's No. 685, 6 June, 1940. Skin and skull.
Paratypes: ♂ 50.1117, collector's No. 595, 1118, collector's No. 598, ♀ 1119, collector's No. 593, Tapu, Upper Ramu Plateau, 6,000 ft.; ♂ 1113, collector's No. 667, 1115, collector's No. 690, 1120, collector's No. 663 [in spirit], ♀ 1116, collector's No. 635, Baiyanka, Purari-Ramu Divide, SE. Bismarck Range, 7,500 ft.

This is a small and rather slender race of *Murexia longicaudata*. The general colour of the pelage is similar to that of *l. longicaudata* but is a little longer and softer, the hairs on the back being about 7 mm. long, finely grizzled mouse-grey dorsally and silvery grey or buffy grey ventrally; the hands and feet are pale brown and the long tail is covered with short, light brown hairs except at the tip, where for a distance of from 10 to 47 mm. or so the hairs are white. The hairs are longer on the underpart of the tail and project beyond the tip.

Skull similar to that of *l. longicaudata* but much smaller.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	Sex	Head and body	Tail	Hind foot	Ear	Condylo-basal length	Zygomatic breadth	Nasals	Inter-orbital breadth	Outer corners m^3
50.1114 Type	♂	132	175	26	19·5	34·3	19·1	13·2×4·9	7·7	10·9
1113	♂	131	173	26	18	33·3	18·2	11·9×4·1	7·8	10·0
1115	♂	127	154	25·5	20	32·3	17·1	12·4×4·4	8·0	9·9
1116	♀	115	148	23	17	30·9	16·5	11·0×3·5	7·3	9·8
1119	♀	122	153	24	17	31·5	16·7	11·7×4·5	7·4	9·9
1117	♂	109	150	25	17	30·0	—	10·8×3·7	7·0	9·9
1118	♂	123	161	25	19	33·0	17·4	12·4×3·8	7·8	10·4

Number	m^{1-3}	Breadth brain case	Palatal length	Anterior palatal foramina	Width mesopterygoid fossa	Width inside m^1–m^1	m^1	m^2	m^3	m^4
50.1114 Type	6·8	13·5	18·6	3·6	4·0	5·0	2·5×1·7	2·4×2·0	2·1×2·3	1·8×2·4
1113	6·9	13·0	18·3	—	3·6	4·4	2·5×1·8	2·3×2·1	2·1×2·4	1·8×2·4
1115	6·8	13·0	18·2	3·4	3·2	4·5	2·5×1·7	2·4×2·1	2·2×2·4	1·6×2·1
1116	6·7	12·5	17·0	3·4	3·6	4·0	2·4×1·6	2·3×2·1	2·1×2·3	1·7×2·4
1119	6·6	12·4	17·1	3·4	3·5	4·5	2·4×1·6	2·3×2·1	2·1×2·3	1·7×2·2
1117	6·9	12·0	16·5	3·2	3·2	3·9	2·4×1·6	2·3×2·0	2·0×2·3	1·7×2·3
1118	7·0	13·1	18·3	3·6	3·6	4·8	2·5×1·7	2·4×2·1	2·1×2·3	1·8×2·4

Murexia rothschildi (Tate)

Phascogale (*Murexia*) *rothschildi* Tate, 1938, *Novit. Zool.* **41:** 58.
Type locality: Aroa River, Papua, probable altitude ± 4,000 ft.
Murexia rothschildi (Tate), 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 118.

Six specimens all from eastern Papua: ♂ 50.1107, Ikara, NE. slope Mt. Simpson; ♂ 1109, 1108, juv. ♀ 1110 (skull and unstuffed skin), Enaena, NE. slope Mt. Simpson; ♂ 1111, ♀ 1112, Boneno, Mt. Mura.

The only specimens of this interesting species which appear to have been previously recorded are the type—Tring Museum, Field No. 1, a male, and another male collected by the same collector on the same day, A.M.N.H. No. 108106. It is easily distinguished from *longicaudata* and its various races by the broad black mid-dorsal stripe.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Outer corners m^3*	*m^{1-3}*
50.1107	♂	156	178	29	21·5	39·8	20·0	14·8×6·0	7·4	11·9	7·7
1109	♂	154	184	27	20	38·0	21·7	13·0×5·5	7·2	11·9	7·5
1108	♂	150	162	26	20	38·1	21·5	13·7×5·5	7·8	12·4	7·8
1111	♂	132	163	27	19	34·0	18·8	12·0×4·0	7·8	11·6	7·8
1112	♀	124	152	25	19	31·9	17·8	11·0×4·0	7·6	11·2	7·7

Antechinus melanurus (Thomas)

Phascogale melanura Thomas, 1899, *Ann. Mus. Stor. nat. Genova,* **40:** 191.
Type locality: Moroka, British New Guinea, 1,300 m.
Phascogale melanura modesta Thomas, 1912, *Ann. Mag. Nat. Hist.* **9:** 92.
Type locality: Mt. Goliath, Dutch New Guinea.
Antechinus melanurus (Thomas), Tate, 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 129.

Thirteen specimens. Five from eastern Papua: ♂ 50.1103, young ad. ♂ 1102, ♀ 1104, 1105, Enaena, NE. slopes Mt. Simpson; ♂ 1106, Boneno, Mt. Mura; and eight from NE. New Guinea: ♂ 1100, 1101, Baiyanka, SE. Bismarck Range; ♂ 1834, 1835, 1836, (♂ 1837, ♀ 1838, in spirit), Tomba, SW. slopes Hagen Range; ♂ 1839, Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

The general colour of all the specimens is very similar; the orange patch of hair behind the ears is not so well developed in the two specimens from the Bismarck Range and the one from Degabaga.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Outer corners m^3*	*m^{1-3}*
50.1103	♂	123	142	23	17	31·2	17·9	10·9×4·8	7·1	9·7	5·6
1102	y. ad. ♂	111	137	22	17	29·5	16·7	9·8×3·9	7·3	9·6	6·1
1104	♀	115	143	22	17	30·0	17·5	11·2×4·0	7·3	9·5	6·0
1105	♀	112	135	21·5	16·5	29·8	17·7	10·8×4·0	7·5	9·9	6·0
1106	♂	112	130	22	16	28·4	17·5	9·8×4·1	7·2	9·7	5·8
1100	♂	114	140	22	16	29·0	17·0	10·8×4·0	7·3	9·7	6·0
1101	♂	103	122	21	16	26·7	16·2	9·8×3·9	7·2	9·0	5·7
1834	♂	107	129	21	16	28·4	16·3	10·0×4·5	7·0	8·8	6·0
1835	♂	99	125	21	15	27·0	15·8	10·0×4·2	6·5	9·2	5·9
1836	♂	110	138	22·5	15	30·5	17·2	12·0×4·9	7·2	9·5	6·0
1839	♂	115	144	22	16	29·0	17·5	11·0×4·0	7·9	9·5	5·7
1837	♂	—	—	—	—	28·4	16·5	10·8×4·4	6·9	9·2	6·0
1838	♀	—	—	—	—	27·9	16·4	10·5×4·4	7·0	9·1	5·8

Antechinus hageni sp. n.

Type locality: Tomba, SW slopes Hagen Range, Central Highlands, NE. New Guinea, 8,200 ft.

Type: Adult ♂ 50.1829, collector's No. 1097, 30 June 1947. Skin and skull.

Paratypes: young ad. ♀ 50.1830, collector's No. 1101, (♂ 1831, collector's No. 1111, 1832, collector's No. 1115, in spirit), Tomba, SW. slopes Hagen Range, NE. New Guinea, 8,200 ft.; ♀ 1833, collector's No. 1052, Yanka, eastern slopes Hagen Range, Central Highlands, NE. New Guinea, 5,500 ft.

The measurements of this small species are very similar to those for *A. wilhelmina* and from its general body colouring it appears to belong to Tate's *A. flavipes* group which, in New Guinea, contains *melanurus*, *mayeri*, *centralis*, *tafa*, *misim*, and *wilhelmina*. The general body colour is a uniform brownish-grey, the bases of the hairs grey, the tips yellowish-brown. The rump is not contrastingly reddish as in *wilhelmina*. There are no ear patches. The hairs on the underparts are grey based and tipped with white. The hands and feet are pale brown, the digits buffy. The tail is brown above and pale buffy below.

Measurements in mm. of the type and paratypes (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Palatal length*	*Posterior palatal foramina*	*i^1–m^4*	*m^{1-4}*	*m^{1-3}*	*Width m^1*	*Outer corners m^3*
50.1829 Type	♂	109	125	21	17·5	29·6	16·0	12·5×4·5	7·8	16·3	4·3	15·5	6·3	5·5	1·4	8·9
1830	y. ad. ♀	96	131	20	18	28·3	15·0	11·5×3·5	7·6	15·2	4·8	14·9	6·3	5·4	1·4	9·0
1833	♀	105	119	20	17	28·2	14·7	11·5×3·8	7·6	15·5	3·8	14·9	6·3	5·5	1·4	9·0
1831	♂	—	—	—	—	29·9	17·1	11·5×4·9	8·0	16·5	5·0	15·5	6·3	5·6	1·4	9·4
1832	♂	—	—	—	—	27·5	15·0	— ×3·5	7·8	—	c. 4·5	14·3	6·2	5·5	1·4	8·9

Phascolosorex dorsalis whartoni (Tate & Archbold)

Phascogale (*Phascolosorex*) *dorsalis whartoni* Tate & Archbold, 1936, *Amer. Mus. Novit.*, No. 823: 4.
Type locality: Eastern slope of Mt. Tafa, Central Division of Papua, 2,070 metres.
Phascolosorex dorsalis whartoni (Tate & Archbold), Tate, 1947, *Bull. Amer. Mus. Nat. Hist.* **88:** 138.

Six specimens, all from NE. New Guinea: ♂ 50.1098, 1095, 1097, 1096, ♀ 1099, Baiyanka, SE. Bismarck Range; ♀ 1807, Menebe, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Mastoidal breadth*
50.1098	♂	166	143	25·5	21	39·0	22·5	15·7×6·1	8·3	16·1
1095	♂	162	137*	26·5	21	40·4	21·2	15·7×5·7	7·0	16·6
1097	♂	144	128	25·0	19	37·0	20·2	13·7×5·9	8·0	15·1
1096	♂	138	135	25·0	18	36·4	19·8	13·7×5·6	8·4	15·0
1099	♀	123	119	23·5	18	34·0	17·6	11·8×5·0	7·9	14·2
1807	♀	119	123	24·0	16	33·4	16·5	12·6×5·4	8·1	13·4

Number	*Palatal length*	*Anterior palatal foramina*	*Posterior palatal foramina*	p^4	m^1	m^2	m^3	*Outer corners* m^3	m^{1-3}
50.1098	20·8	3·6	4·0	1·0	2·5×1·6	2·3×2·0	2·2×2·2	11·1	7·0
1095	22·0	3·8	4·0	1·0	2·4×1·6	2·3×2·0	2·2×2·4	10·7	6·8
1097	20·2	3·6	4·1	1·0	2·6×1·7	2·6×2·1	2·3×2·5	11·0	7·5
1096	19·4	3·5	4·3	0·8	2·4×1·6	2·3×2·0	2·0×2·3	11·0	6·7
1099	—	—	3·2	0·9	2·4×1·6	2·3×2·0	2·2×2·2	10·9	6·9
1807	—	—	—	0·9	2·4×1·5	2·3×1·9	2·1×2·1	10·3	6·8

* Tip broken off.

RODENTIA

Anisomys imitator Thomas

Anisomys imitator Thomas, 1903, *Proc. Zool. Soc. Lond.* **2:** 199–200.
Type locality: Aroa River, British New Guinea.

Three specimens, all from NE. New Guinea: ♂ 50.1159, 1160, Buntibasa district, Kratke Mts.; ♂ 1161, Saiko, Bubu River.

Pogonomys macrourus (Milne-Edwards)

Mus (*Pogonomys*) *macrourus* Milne-Edwards, 1877, *C.R. Acad. Sci. Paris*, **85:** 1081.
Type locality: Arfak, Dutch New Guinea.
Pogonomys lepidus Thomas, 1897, *Ann. Mus. Stor. nat. Genova*, **38:** 614.
Type locality: Haveri, Astrolabe Range, Papua.
Pogonomys lepidus huon Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 803: 6.
Type locality: Huon Peninsula, Dutch New Guinea.
Pogonomys lepidus derimapa Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 803: 6.
Type locality: Mount Derimapa, Dutch New Guinea.

Seventeen specimens. Fourteen from NE. New Guinea: two from the Kratke Mts., ♂ 50.1167, Buntibasa district and ♂ 1168 from Kambaidam; six from Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide, ♂ 1648, 1651, 1650, juv. ♂ 1649, ♀ 1653, 1652; four from Junzaing, Huon Peninsula, ♂ 1655, 1654, ♀ 1656, 1657; two from Mendi, Bismarck Range, ♂ 1658, ♀ 1659; and three from eastern Papua: juv. ♂ 47.1283, Enaena, NE. slopes Mt. Simpson; juv. ♂ 47.1284, ♀ 47.1285, Boneno, Mt. Mura.

The difference in colour between the juvenile and adult pelage is clearly indicated in this series. That of the younger animals, especially No. 47.1283, is grey with a very light overwash of yellowish-brown; that of the adult is a bright yellowish-brown. The measurements indicate the amount of variability in the species.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal foramina*	m^{1-3}	m^1
47·1285	♀	129	178	23	15	30·4	18·9	11·2	4·4	16·4	4·9	5·7	2·5 × 1·9
50.1167	♂	117	176	24	14	29·3	18·0	10·6	4·5	15·5	4·1	5·4	2·4 × 1·7
1168	♂	125	175	24	15	30·7	17·5	11·1	4·4	16·4	3·8	5·6	2·5 × 1·7
1648	♂	130	182	24	15	30·9	17·5	11·8	4·6	16·3	3·7	5·2	2·3 × 1·6
1651	♂	119	165	22·5	14	29·0	16·9	10·7	4·7	15·2	3·9	5·2	2·3 × 1·7
1650	♂	114	177	23·5	13	29·4	16·4	10·9	4·8	15·7	3·9	5·1	2·2 × 1·6
1653	♀	127	176	23	14	30·6	17·6	11·3	4·8	16·2	3·9	4·9	2·2 × 1·6
1652	♀	114	164	23·5	14	28·6	16·4	10·1	4·6	15·0	3·9	5·0	2·3 × 1·6
1655	♂	126	187	23	16	30·8	17·3	10·9	4·9	16·7	4·3	5·5	2·5 × 1·7
1654	♂	125	178	23	16·5	31·0	18·1	—	4·7	16·5	4·4	5·5	2·5 × 1·8
1656	♀	129	173	23	15	30·5	17·3	10·5	4·5	16·2	4·5	5·7	2·5 × 1·8
1657	♀	128	177	23	16	31·2	18·3	10·8	4·1	16·9	4·2	5·4	2·5 × 1·7
1658	♂	117	195	25	14	29·8	17·3	—	4·7	16·0	3·8	5·5	2·5 × 1·8
1659	♀	115	210	25	14·5	30·8	17·5	10·9	4·7	16·8	4·1	5·5	2·5 × 1·8

Pogonomys mollipilosus (Peters & Doria)*

Mus mollipilosus Peters & Doria, 1881, *Ann. Mus. Stor. nat. Genova*, **36:** 698.
Type locality: Katau, Oriomo River, Daru, S. New Guinea.

Thirty-one specimens. Eight from eastern Papua: ♂ 47.1252, 1253, 1255, juv.

* *See* Tate, 1951: 280, for synonyms.

♂ 1251, ♀ 47.1244, 1254, 1256, 1257, Enaena, NE. slopes Mt. Simpson; and twenty-three from NE. New Guinea: ♂ 47.1242, 1243, Baiyanka, SE. Bismarck Range; ♂ 47.1245, ♀ 47.1247, 1249, 1250, juv. ♀ 1246, juv. ♀ 1248, Tapu, Upper Ramu River Plateau; ♂ 50.1169, ♀ 50.1170, Kambaidam, Kratke Mts.; ♂ 50.1171, 1172, ♀ 50.1173, 1174, Buntibasa district, Kratke Mts.; ♂ 50.1665, 1666, 1667, ♀ 50.1668, Yandara, Bismarck Range; ♂ 50.1661, 1660, ♀ 50.1663, 1662, [♀ 50.1661 in spirit], Tomba, SW. slopes Hagen Range.

This series shows a tendency, which is particularly marked in the specimens from Yandara and Tomba, for the line of demarcation between the yellowish-brown dorsal pelage and white ventral pelage to become indistinct. This is completely so in No. 50.1660 where the colour of the dorsal pelage merges with that of the under-surface, which is yellowish-whitish-grey.

Pogonomys sylvestris Thomas

Pogonomys sylvestris Thomas, 1920, *Ann. Mag. Nat. Hist.* **9:** 534.
Type locality: Rawlinson Mountains, New Guinea.

Thirty-five specimens. Twenty-three from NE. New Guinea: ♂ 47.1268, 1269, 1273, juv. ♂ 1270*a*, juv. ♂ 1274, ♀ 47.1270, 1270*b*, Baiyanka, SE. Bismarck Range; ♂ 50.1162, Saiko, Bubu River; ♂ 50.1684, 1685, 1686, ♀ 50.1688, 1689, Yandara, Bismarck Range; ♂ 50.1693, ♀ 50.1690, 1691, Yanka, eastern slopes Hagen Range; ♂ 50.1695, 1694, ♀ 50.1696, [♂ 50.1697, juv. ♀ 50.1698 in spirit], Tomba, SW. slopes Hagen Range; ♀ 50.1692, Degabaga, 8 miles east Hagen Range, Sepik-Wahgi Divide; and twelve from eastern Papua: ♂ 47.1272*a*, ♀ 47.1271, 1272, Boneno, Mt. Mura; ♂ 47.1275, 1276, 1277, 1278, 1282*a*, ♀ 47.1279, 1280, 1281, 1282, Enaena, NE. slopes Mt. Simpson.

Pogonomys fergussoniensis sp. n.

Type Locality: Taibutu, Faralulu district, West Fergusson Island.
Type: Adult ♂ 50.1175, collector's No. 424, 21 July 1935. Skin and skull.
Paratype: ♂ 50.1176, collector's No. 427 (skull only), Taibutu, Faralulu district, West Fergusson Island.

These specimens are most nearly allied to *P. mollipilosus*. They are larger. The general colour is a rusty brown and there is no sharp line of demarcation between the dorsal and ventral pelage. Dorsally the pelage consists of grey based hairs with russet tips, and longer fuscous hairs. Ventrally the pelage is whitish-buff with patches of rust-coloured hairs. The hairs on the fore and hind feet are buff and there is a band of dark hairs on the upper side of the wrists. Tail fuscous with light patches. Ears fuscous.

Skull larger and more heavily built than that of *mollipilosus*; temporal ridges prominent.

Measurements in mm. of the type and paratype (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Diastema*	*Palatal length*	*Palatal foramina*	m^{1-3}	m^1
50.1175 Type	♂	167	249	29	15	37·7	22·8	14·0	4·9	10·6	20·5	4·5	7·3	3·5×2·4
1176	♂	—	—	—	—	35·0	20·7	12·5	3·9	10·2	19·3	4·4	7·3	3·5×2·4

Pogonomys forbesi (Thomas)

Chiruromys forbesi Thomas, 1888, *Proc. Zool. Soc. Lond.* **1888:** 239.
Type locality: Sogere, SE. New Guinea.
Chiruromys pulcher Thomas, 1895, *Novit. Zool.* **2:** 164.
Type locality: Fergusson Island, D'Entrecasteaux group. (Status *fide* Rümmler.)
Pogonomys forbesi vulturnus Thomas, 1920, *Ann. Mag. Nat. Hist.* **9:** 535.
Type locality: Milne Bay, SE. Papua.
Pogonomys forbesi mambatus Thomas, 1920, *Ann. Mag. Nat. Hist.* **9:** 536.
Type locality: Kokoda, Mambare River, NE. New Guinea.
Pogonomys (*Chiruromys*) *forbesi satisfactus* Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 803: 7.
Type locality: Goodenough Island, D'Entrecasteaux group.
Pogonomys (*Chiruromys*) *pulcher major* Tate & Archbold, 1935, *Amer. Mus. Novit.*, No. 803: 8.
Type locality: Goodenough Island, D'Entrecasteaux group. (Status *fide* Rümmler.)

Eight specimens. Four from Garaina, Upper Waria River, NE. New Guinea: ♂ 50.1163, 1164, ♀ 1165, 1166; and four from Wapona, north slope Manaeo Range (35 miles NW. Mt. Simpson), eastern Papua: ♂ 47.1264, ♀ 1265, 1266, juv. ♀ 1266*a*.

Pogonomys lamia Thomas

Pogonomys lamia Thomas, 1897, *Ann. Mus. Stor. nat. Genova*, **38:** 615.
Type locality: Ighibirei, Upper Kemp Welch River, Central British New Guinea.

Eight specimens, all from eastern Papua: ♂ 47.1258, 1259, 1260, Enaena, NE. slopes Mt. Simpson; ♂ 1261, 1267 juv. of ♀ 1262, 1262*a*, ♀ 1262, Boneno, Mt. Mura; ♂ 1263, Ikara, NE. ridge Mt. Simpson.

Pogonomys shawmayeri sp. n.

Type locality: Taibutu, Faralulu district, West Fergusson Island, 900 ft.
Type: Adult ♂ 50.1177, collector's No. 419, 17 July 1935. Skin and skull.
Paratype: ♀ 50.1178, collector's No. 420, Taibutu, Faralulu district, West Fergusson Island, 900 ft.

These specimens appear to be closely related to *Chiruromys pulcher* Thomas, 1895, type locality Fergusson Island, which Rümmler (1938) describes as a synonym of *forbesi*. They are, however, larger, particularly when compared with the specimens, in this collection, of *forbesi* from the mainland and are at once distinguished by the

much thicker tail which is covered with coarse brownish-black scales. As in the type of *pulcher* the fur is longer and softer than that of typical *forbesi*, the hairs in the middle of the back being about 15 mm. long. The general colour, however, is very similar to that of *forbesi*, a soft rufous brown instead of the reddish colour of *pulcher*, and the underside is creamy white instead of russet. There is a dark band running from the sides of the muzzle which joins the dark ring round the eye. The feet and hands are whitish. The tail has coarse scales which are all keeled and almost black in colour; in *pulcher* they are brown and only some are keeled. The skull is fairly similar to that of the types of *pulcher* and *forbesi*, the most noticeable difference being the somewhat broader brain-case (mastoidal breadth 16·2 mm. and *c.* 16·0 mm. in *shawmayeri*; 15·3 mm. in type of *pulcher*; 14·0 mm. in type of *forbesi*).

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Inter-orbital breadth*	*Nasals*	*Diastema*	*Palatal foramina*	*Palatal length*	m^{1-3}	m^1
50.1177 Type	♂	156	248	29	20·5	36·9	*c.*22·5	6·0	12·6×4·0	11·0	5·0	19·0	5·8	2·6×1·9
1178	♀	155	232	29	20·5	—	21·7	5·7	11·8×3·9	10·8	4·6	18·1	5·7	2·6×1·9

Hyomys goliath goliath (Milne-Edwards)

Mus goliath Milne-Edwards, 1900, *Bull. Mus. Hist. Nat., Paris*, **6**: 165.
Type locality: Aroa River, British New Guinea, 3,000–7,000 ft.
Hyomys meeki Thomas, 1903, *Proc. Zool. Soc. Lond.* **2**: 198.
Type locality: Avera, Aroa River, British New Guinea.

Fifteen specimens, all from NE. New Guinea: ♀ 50.1179, Kuraka, Kratke Mts.; ♂ 1180, 1181, juv. ♂ 1183, juv. ♂ 1182, ♀ 1184, Buntibasa district, Kratke Mts.; ♂ 1185, 1186, Arau district, Kratke Mts.; juv. ♀ 1187, Saiko, and ♂ 1188, Bubu River district; ♀ 1189, 1190, Zageheme, Cromwell Mts., Huon Peninsula [in spirit]; ♂ 1681, ♀ 1682, Yanka, eastern slopes Hagen Range; juv. ♀ 1683, Menebe, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

Mallomys rothschildi Thomas subsp.

Range: New Guinea and (?) Flores.

Forty-eight specimens. Thirteen from eastern Papua: young ad. ♂ 47.1344, ♀ 1345, 1346, 1347, Boneno, Mt. Mura; young ad. ♀ 1341, Ikara, NE. slopes Mt. Simpson; ♂ 1349, 1350, young ad. ♂ 1348, ♀ 1352, 1353, 1355, young ad. ♀ 1354, juv. ♀ 1351, Enaena, NE. ridge Mt. Simpson; and thirty-five from NE. New Guinea: ♂ 50.1193, 1194, 1195, juv. ♂ 1196, ♀ 1197, 1198, Saiko, Bubu River; ♂ 1192, Buntibasa district, Kratke Mts.; ♀ 1191, Kuraka, Kratke Mts.; ♂ 47.1342, ♀ 47.1343, Tapu, Upper Ramu River Plateau; ♂ 47.1334, 1335, 1339, ♀ 47.1336, 1337, juv. ♀ 1338, young ad. ♀ 1340, Baiyanka, SE. Bismarck Range; ♂ 50.1780, 1781, 1782, Guyebi, Bismarck Range; ♂ 1784, 1785, 1786, 1787, juv. ♂ 1783, ♀ 1788, Yanka, eastern slopes Hagen Range; ♂ 1789, 1790, ♀ 1791, Tomba, SW. slopes Hagen Range;

♂ 1792, ♀ 1793, 1794, 1795, Menebe, 8 miles east of Hagen Range, Sepik-Wahgi Divide; ♂ 1796, ♀ 1797, Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

This excellent collection of skins from a number of localities, ranging from the Hagen Range in the north to Mt. Simpson in the south, indicates that there is a great deal of variation in the colour and texture of the pelage of this species, from blackish and brownish-grey to dark brown. Both grey and brown forms occur together though the really dark brown specimens have so far only occurred in collections from the Bismarck and Hagen Ranges. Another variation in coat colour, which occurs in both grey and brown forms, is the presence of a band of white hairs across the middle of the underside which may go round on to the back (Nos. 50.1786, 50.1790 and 50.1791). Specimen No. 50.1789 has a few white hairs in the middle of its side.

Measurements in mm. (taken in the flesh):

Locality	*Number*	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Palatal length*	*Nasals*	*Anterior palatal foramina*	m^{1-3}
Ikara, Mt. Simpson, eastern Papua	47.1341	y. ad. ♀	363	380	70	29	—	—	—	—	—	—
Boneno, Mt. Mura, eastern Papua	47.1344	y. ad. ♂	359	396	76·5	29	72·9	36·4	39·6	29·7	15·2	17·0
	1345	♀	371	382	68	30	—	—	—	—	—	—
	1346	♀	410	400	74	30	79·3	41·8	43·0	32·0	15·5	17·1
	1347	♀	406	416	74	30	—	—	—	—	—	—
Enaena, Mt. Simpson, eastern Papua	47.1349	♂	374	368	69	30	—	—	—	—	—	—
	1350	♂	377	391	72	30	—	—	—	—	—	—
	1348	y. ad. ♂	362	408	74	29	—	—	—	—	—	—
	1352	♀	354	386	69	28	72·6	40·0	40·4	28·8	15·3	17·5
	1353	♀	384	387	73	30	—	—	—	—	—	—
	1355	♀	376	416	72	29	—	—	—	—	—	—
	1354	y. ad. ♀	357	386	71	27	—	—	—	—	—	—
Saiko, Bubu River, NE. New Guinea	50.1193	♂	384	382	72	28·5	75·9	39·7	42·4	30·7	15·5	16·3
	1194	♂	398	360	67·5	31	—	—	—	—	—	—
	1195	♂	390	400	72	30	74·2	38·9	43·7	30·4	15·3	17·4
	1197	♀	360	365	70	29	—	—	—	—	—	—
	1198	♀	378	384	71	31	—	—	—	—	—	—
Buntibasa district, Kratke Mts. NE. New Guinea	50.1192	♂	346	416	70	28	—	—	—	—	—	—
Kuraka, NE. New Guinea	50.1191	♀	368	375	67	27·5	—	—	—	—	—	—
Tapu, Upper Ramu River Plateau, NE. New Guinea	47.1342	♂	378	350	68	27	—	—	—	—	—	—
	1343	♀	322	335	65	27	—	—	—	—	—	—
Baiyanka, Bismarck Range, NE. New Guinea	47.1334*	♂	391	395	70	30	73·9	37·4	41·4	29·8	14·6	17·7
	1335*	♂	370	382	66	30	70·3	38·1	40·0	27·0	14·1	17·0
	1339	♂	375	295†	74	27	—	—	—	—	—	—
	1336*	♀	357	413	70	30	71·0	36·0	39·8	28·7	13·6	16·6
	1337*	♀	376	410	70	30	71·9	38·1	40·1	27·4	14·1	17·1
	1340	y. ad. ♀	374	394	73	28	—	—	—	—	—	—
Guyebi, Bismarck Range, NE. New Guinea	50.1780*	♂	367	380	68	28	—	—	—	—	—	—
	1781	♂	360	394	73	30	—	—	—	—	—	—
	1782	♂	376	364	70	29·5	—	—	—	—	—	—
Yanka, Hagen Range, NE. New Guinea	50.1784*	♂	384	400	70	30	71·5	39·4	40·1	28·0	14·0	17·0
	1785*	♂	364	396	68	29	—	—	—	—	—	—
	1786*	♂	353	354	70	30	71·1	37·0	40·5	29·4	15·2	17·0
	1787*	♂	365	382	71	30	—	—	—	—	—	—
	1788	♀	406	353	71	33	—	—	—	—	—	—
Tomba, Hagen Range, NE. New Guinea	50.1789*	♂	355	385	70	31	70·1	36·4	39·4	27·9	13·9	17·5
	1790*	♂	369	337	68	29	—	—	—	—	—	—
	1791	♀	344	348	68	29	69·8	36·7	39·6	28·0	14·2	17·0
Menebe, Nr. Hagen Range, NE. New Guinea	50.1792*	♂	350	380	68	28	—	—	—	—	—	—
	1793	♀	372	355	71	31	75·2	40·7	44·1	33·9	14·5	17·8
	1794	♀	401	408	76	29	—	—	—	—	—	—
	1795	♀	385	405	71	27	—	—	—	—	—	—
Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide, NE. New Guinea	1796	♂	389	373	71·5	27	—	—	—	—	—	—
	1797	♀	363	378	69	26	—	—	—	—	—	—

* Dark brown specimens. † Tip broken off.

Rattus exulans exulans (Peale)

Mus exulans Peale, 1848, *U.S. Exploring Expedition. . . . 1838–42. Under the command of C. Wilkes*, **8**: 47, Philadephia.
Type locality: Fiji Isands.

Three specimens from Tongoa Island, New Hebrides: ♂ 50.1200, juv. ♀ 50.1201 skull only, ?50.1202 skull only.

Rattus exulans browni (Alston)

Mus browni Alston, 1877, *Proc. Zool. Soc. Lond.* **1877**: 123.
Type locality: Duke of York Island.
Mus echimyoides Ramsay, 1877, *Proc. Linn. Soc. N.S.W.* **2**: 15.
Type locality: Duke of York Island.

Nineteen specimens. Fourteen from NE. New Guinea: ♂ 50.1205, 1206, Kambaidam, Kratke Mts.; ♂ 47.1131, 1132, 1133, ♀ 47.1134, Tapu, Upper Ramu River Plateau; ♀ 47,1135, Baiyanka, SE. Bismarck Range; ♂ 50.1751, 1752, 1753, 1754, 1755, ♀ 50.1756, 1757, Yandara, Bismarck Range; three from eastern Papua: ♂ 47.1138, Ikara, NE. slopes Mt. Simpson; ♂ 47.1139, ♀ 47.1140, Boneno, Mt. Mura; and two, ♂ 47.1136, ♀ 47.1137, from Lau, Bainings Mts., Gazelle Peninsula, New Britain.

Rattus ruber tramitius Thomas

Rattus mordax tramitius Thomas, 1922, *Ann. Mag. Nat. Hist.* **9**: 262.
Type locality: Mamberano-Idenburg region (Doormanpad-bivak), N. Dutch New Guinea.
Rattus leucopus utakwa Rümmler, 1935, *Z. Säugertierk.* **10**: 115.
Type locality: Camp No. 3, Utakwa River, 2,000 ft.
Rattus mordax hageni Troughton, 1937, *Rec. Aust. Mus.* **20**: 120.
Type locality: Upper Wahgi River, south slopes of Mt. Hagen, south of Sepik Division, New Guinea.

Nineteen specimens. Seventeen from NE. New Guinea: three, ♂ 50.1208, 1209, ♀ 1210, from Saiko, Bubu River; twelve, ♂ 1737, 1738, 1740, 1741, 1742, 1739, ♀ 1748, 1746, 1747, 1743, 1745, 1744, from Yandara, Bismarck Range; two, ♂ 1749, ♀ 1750, from Yanka, eastern slopes Hagen Range; and two from eastern Papua: ♀ 47.1156, Enaena, NE. slopes Mt. Simpson; ♀ 47.1159, Boneno, Mt. Mura.

Tate (1951: 331, 333) suggests that *Rattus ruber hageni* from the Mt. Hagen area, north-east New Guinea, is possibly the same as *R. ruber tramitius* from the mountains south of the Idenburg River, north Netherlands New Guinea, with which *utakwa* from south-west Netherlands New Guinea is synonymized. Two of the nineteen specimens in this collection came from the eastern slopes of Mt. Hagen; twelve from the neighbouring Bismarck Range; three from the Bubu River (Upper Warai River), south-eastern north-east New Guinea; one from Mt. Mura; and one from Mt. Simpson, eastern Papua. The general colour of the specimens varies from the 'buffy-ochraceous' of the type of *hageni* to the 'blackish-grey very finely ticked with buffy' of the type of *tramitius*, and the range of the measurements of the skins and skulls includes those of *tramitius* and *hageni*, so that it is impossible to separate the two.

Tate (1951: 333) states that the mammary formula of *hageni* is unknown and that therefore it may be a race of *verecundus* or *leucopus*. But Troughton in his description of the type gives the mammary formula as 2–2=8.

The following are the measurements of the skins of six adult males and ten adult females, and of the skulls of seven adult males and six adult females, of *tramitius*.

	Extremes		*Average*		*Standard deviation*	
	♂	♀	♂	♀	♂	♀
Head and body	152–175	135–172	162	152	7·8	9·2
Tail	133–155	127–153	144	135	9·2	7·5
Hind foot	32–35	30–34	34	32	1·3	1·6
Ear	19–21·5	18–21	19·8	19	1·2	1·2
Condylo-basal length	37–39·3	34·9–39·6	38·7	37·2	1·0	1·7
Zygomatic breadth	18·3–21·4	18·7–21·2	19·7	19·9	1·0	1·0
Inter-orbital breadth	5·8–6·1	5·6–6·2	5·9	5·9	0·1	0·2
m^{1-3}	6·6–7·3	6·7–7·4	7·0	7·1	0·3	0·3
m^1 length	3·2–3·9	3·1–3·6	3·5	3·4	0·3	0·2
m^1 breadth	2·1–2·6	2·1–2·6	2·3	2·3	0·2	0·2

Rattus ruber fergussoniensis subsp. n.

Type locality: Faralulu district, West Fergusson Island, SE. New Guinea, *c.* 900 ft.

Type: Adult ♂ 50.1211, collector's No. 436, 31 July 1935. Skin and skull.

Paratype: ♀ 50.1212, collector's No. 441, skull only, Faralulu district, West Fergusson Island, SE. New Guinea, *c.* 900 ft.

This short-tailed rat is most closely related to *R. ringens feliceus* (Ellerman, 1949) and *R. ringens coenorum* (? = *bandiculus*). Its size, proportionate length of tail to body, and the size of the scales on the tail (6–7 rings per cm.) make it very similar to *feliceus*. The general colour, however, is much darker and is similar to that of *coenorum*, a grizzled brownish-grey, only it is suffused with russet. This colour occurs in irregular streaks on the sides and under surface which is otherwise buffy grey.

The skull is not quite as large as, but is most closely allied to, that of the type of *bandiculus*, which may be synonymous with *coenorum* (*see* Tate, 1951, p. 332). The palatal foramina are straighter and narrower and the molar teeth are arranged in a slight curve instead of in the straight almost parallel lines of *coenorum*.

Measurements in mm. of the type and paratype (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals*	*Inter-orbital breadth*	*Diastema*	*Palatal length*	*Palatal foramina*	m^{1-3}	m^1
50.1211 Type	♂	225	194	41	22	50	25·3	19·5×6·2	6·8	3·4	28·7	9·6	8·9	4·3×2·5
1212	♀	—	—	—	—	46·9	25·0	19·0×5·2	7·0	2·3	27·7	8·6	8·6	4·0×2·5

Rattus ruber rosalinda Hinton

Rattus rosalinda Hinton, 1943, *Ann. Mag. Nat. Hist.* **10:** 557.
Type locality: Tapu, Upper Ramu River Plateau, NE. New Guinea.

One additional specimen, ♀ 50.1207 from Kambaidam, Kratke Mts., NE. New Guinea, to the eight specimens which include the type from Tapu, NE. New Guinea.

Rattus niobe haymani Ellerman

Stenomys klossi Thomas, 1913, *Ann. Mag. Nat. Hist.* **12:** 207 (preoccupied).
Type locality: Upper Utakwa River, Dutch New Guinea, 5,500 ft.
Rattus niobe haymani Ellerman, 1941, *The families and genera of living rodents*, **2**: 206 (new name).

One specimen, ♂ 50.1765, from Yanka, eastern slopes Hagen Range, Central Highlands, NE. New Guinea.

Rattus verecundus tomba subsp. n.

Type locality: Tomba, SW. slopes Hagen Range, Central Highlands, NE. New Guinea, 8,500 ft.
Type: Adult ♂ 50.1766, collector's No. 1093, 27 June 1947. Skin and skull.

This specimen seems to be most nearly allied to *R. v. mollis* Rümmler, 1935, from Morobe, Mt. Misim, Papua, 5,850 ft. It is smaller than *R. v. verecundus*. The pelage is fine, long and soft, and the hairs on the back, which are about 6 mm. long, are dark grey tipped with yellowish-brown. On the under surface they are slate-grey tipped with white; a few are tipped with yellow. The feet and hands are white and there is a white spot on the chest. The tail is covered with short fine yellowish-brown hairs except for about 42 mm. at the tip where the hairs are white.

The skull is smaller and lighter than that of *R. v. verecundus*; the temporal ridge is barely visible; and the anterior palatal foramina are pointed at both ends, not more rounded posteriorly as in *R. v. verecundus*.

Measurements in mm. of the type (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Palatal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Diastema*	*Palatal foramina*	*Bulla length*	m^{1-3}
50.1766 Type	♂	136	146	32	19	32·3	18·4	16·4	13·3	5·9	9·0	5·6×2·7	5·0	5·8

Rattus shawmayeri Hinton

Rattus shawmayeri Hinton, 1943, *Ann. Mag. Nat. Hist.* **10:** 556.
Type locality: Baiyanka, Purari-Ramu Divide, SE. Bismarck Range, NE. New Guinea.

Eight specimens all from NE. New Guinea: ♂ 50.1763, ♀ 1764, duplicate collector's No. 1143 (skull and piece of skin), high slopes Mt. Wilhelm, Bismarck Range; ♂ 1758, Yandara, Bismarck Range; ♂ 1762, Bogo, south slopes Bismarck Range; ♂ 1761, 1760, Tomba, SW. slopes Hagen Range; ♀ 1759, Yanka, eastern slopes Hagen Range.

These specimens are a useful addition to our collection in which, so far, the type of the species has been the only representative.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal fossa*	*Diastema*	m^{1-3}	m^1 *breadth*
50·1763	♂	103	158	23	18	26·9	15·6	9·9	4·3	14·0	4·6	7·0	4·2	1·3
1764	♀	99	159	23	16·5	25·6	15·9	9·9	4·3	13·5	4·6	7·0	4·3	1·3
1758	♂	101	168	24	17·5	27·0	16·1	10·4	4·4	14·6	5·2	7·8	4·0	1·2
1762	♂	100	146	24	16·5	26·2	15·7	9·9	4·2	13·8	5·0	7·3	4·3	1·3
1761	♂	107	158	24	19	27·2	16·3	9·9	4·3	14·5	4·5	7·3	4·2	1·3
1760	♂	104	150	24·5	18	26·0	15·3	9·8	4·5	13·8	4·7	7·2	4·3	1·3
1759	♀	114	155	25	19	27·4	16·2	10·3	4·7	14·8	5·4	8·2	4·3	1·3

Melomys levipes clarae (Rümmler)

Melomys levipes clarae Rümmler, 1935, *Z. Säugertierk.* **10**: 108.
Type locality: Sumuri Mountain, Weyland Mountains, 2,000 ft.

Two specimens both from NE. New Guinea: ♂ 50.1715, Degabaga, 8 miles east Hagen Range, Sepik-Wahgi Divide; ♀ 1716, Menebe, 8 miles east Hagen Range, Sepik-Wahgi Divide.

These extend the range of *clarae* to NE. New Guinea and to an altitude of 4,500–6,000 ft. The type of *M. l. weylandi* was taken at 5,000 ft. but the measurements of the skulls of these specimens agree with those of the type of *clarae*.

Melomys levipes subsp.

Thirteen specimens identified by Ellerman as a subspecies of *M. levipes*. Eleven from NE. New Guinea: ♂ 47.1202, 1203, 1204, 1205, 1206, 1207, ♀ 1208, 1209, 1210, 1211, 1211*a*, Baiyanka, SE. Bismarck Range; and two from eastern Papua, ♂ 1212, Enaena, Mt. Simpson; ♀ 1213, Ikara, NE. ridge Mt. Simpson.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal foramina*	m^{1-3}	m^1
47·1202	♂	156	158	35	20	35·4	17·5	14·3	6·4	19·9	6·3	8·0	3·8×2·3
1203	♂	150	153	35·5	20	35·7	17·4	14·8	6·6	20·0	6·3	8·0	3·8×2·2
1204	♂	157	160	35	20	36·6	17·3	15·1	6·6	20·9	6·5	7·3	3·8×2·3
1205	♂	157	156	35	20	34·5	17·9	13·8	7·0	19·0	6·0	7·8	3·9×2·4
1206	♂	154	156	35	21	35·7	17·9	15·3	6·9	20·0	5·7	7·9	3·8×2·3
1207	♂	153	156	35	19	35·6	17·8	14·8	6·8	20·4	6·5	7·9	3·9×2·3
1208	♀	146	140	33·5	19	34·2	17·9	13·9	6·6	19·4	6·7	7·8	3·9×2·3
1209	♀	159	166	36	20	35·7	17·7	14·3	6·7	20·0	6·2	7·9	3·9×2·4
1210	♀	152	144	35	19·5	35·3	17·9	14·5	6·5	20·0	6·1	7·9	3·8×2·4
1211	♀	150	153	35	21	34·7	17·4	15·0	6·6	19·5	6·0	8·1	4·0×2·4
1211*a*	♀	144	144	35·5	19	35·8	17·0	13·8	6·5	19·0	6·0	7·8	3·8×2·3

Melomys moncktoni moncktoni (Thomas)

Uromys moncktoni Thomas, 1904, *Ann. Mag. Nat. Hist.* **14:** 399.
Type locality: NE. New Guinea.

Six specimens, all from NE. New Guinea: ♂ 50.1709, 1710, ♀ 1711, 1712, high northern slopes Mt. Wilhelm, Bismarck Range; ♂ 1713, Yandara, Bismarck Range; ♀ 1714, Yanka, eastern slopes Hagen Range.

Melomys lutillus lutillus (Thomas)

Uromys lutillus Thomas, 1913, *Ann. Mag. Nat. Hist.* **12:** 216.
Type locality: Owagarra, Angabunga River, Central Division, Papua.

One specimen, ♀ 47.1214, from Enaena, NE. slopes Mt. Simpson, eastern Papua.

Melomys rufescens rufescens (Alston)

Uromys rufescens Alston, 1877, *Proc. Zool. Soc. Lond.* **1877**: 124.
Type locality: Duke of York Island, between New Britain and New Ireland.
Mus musavora Ramsay, 1877, *Proc. Linn. Soc. N.S.W.* **2**: 16.
Type locality: Duke of York Island.

Twenty-six specimens. Fourteen from NE. New Guinea: ♂ 47.1193, 1195, 1196, juv. ♂ 1194, ♀ 1197, 1198, 1198*a*, Tapu, Upper Ramu River Plateau; ♂ 47.1199, ♀ 1200, 1201, Baiyanka, SE. Bismarck Range; ♀ 50.1213, Kambaidam, Kratke Mts.; ♀ 50.1701, Yandara, Bismarck Range; ♀ 50.1700, Yanka, eastern slopes Hagen Range; ♂ 50.1699, Tomba, SW. slopes Hagen Range; and twelve from eastern Papua: ♂ 47.1184, 1185, 1186, 1187, juv. ♂ 1183, ♀ 1188, 1189, 1190, 1190*a*, 1190*b*, 1191, 1192, Enaena, Mt. Simpson.

Melomys rufescens dollmani Rümmler

Melomys rufescens dollmani Rümmler, 1935., *Z. Säugetierk.* **10:** 106.
Type locality: Buntibasa district, Kratke Mts., NE. New Guinea.

Four specimens, all from NE. New Guinea: one ♂ 47.1215, from Tapu, Upper Ramu River Plateau, and three ♀♀ 50.1718, 1719, 1717, from Tomba, SW. slopes Hagen Range.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Palatal length*	*Anterior palatal foramina*	m^{1-3}	m^1
47·1215	♂	130	184	28	18	31·1	16·7	10·0	5·7	16·1	4·6	5·9	2·9×1·9
50·1718	♀	134	175	29	17·5	31·6	17·5	10·7	5·5	16·6	4·5	6·2	3·0×1·9
1719	♀	141	191	29	18	31·6	16·5	11·4	5·5	16·4	4·2	6·0	3·0×1·9
1717	♀	144	156*	29·5	18	32·3	18·0	11·5	5·8	17·2	4·6	6·1	3·0×1·9

* Tip broken off.

Melomys fellowsi Hinton

Melomys fellowsi Hinton, 1943, *Ann. Mag. Nat. Hist.* **10:** 554.
Type locality: Baiyanka, SE. Bismarck Range, NE. New Guinea, 8,000.

Seventeen specimens, all from NE. New Guinea; type ♂ 47.1175, paratypes ♂ 1174, 1176, 1177, ♀ 1178, 1179, 1180, 1181, juv. ♀ 1181*a*, [? 1182 in spirit], Baiyanka, SE. Bismarck Range; ♀ 50.1704, Yandara, Bismarck Range; ♀ 50.1705, 1706, high northern slopes Mt. Wilhelm, Bismarck Range; ♀ 50.1707, [♂ 1708 in spirit], Tomba, SW. slopes Hagen Range; ♂ 50.1702, ♀ 1703, Yanka, eastern slopes Hagen Range.

The first ten specimens were mentioned by Hinton in 1943 when describing the type. The other specimens are all very similar to these.

Pogonomelomys sevia tatei Hinton

Pogonomelomys tatei Hinton, 1943, *Ann. Mag. Nat. Hist.* **10:** 554.
Type locality: Baiyanka, Purari-Ramu Divide, SE. Bismarck Range, NE. New Guinea, 8,000 ft.

Eight adult specimens, all from NE. New Guinea: seven from Tomba, SW. slopes Hagen Range, ♂ 50.1721, 1720, ♀ 1722, 1723, 1724, [♂ 1725, ♀ 1726 in spirit], and one from the high northern slopes of Mt. Wilhelm, Bismarck Range, ♀ 1727.

These are a useful addition to our collection which only contained the type and two young paratypes. The general colour of all six specimens is a rich reddish-brown. This is the colour of the adult pelage; that of the young specimens is much greyer.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Nasals, length*	*Inter-orbital breadth*	*Diastema*	*Palatal length*	*Palatal foramina*	m^{1-3}	m^1
50.1721	♂	135	173	25	17·5	33·2	19·3	11·5	6·0	9·3	17·6	6·2	6·5	3·0 × 1·7
1720	♂	135	166	25	18	31·6	18·2	*c.* 12·0	5·3	8·4	16·5	5·6	6·4	2·9 × 1·8
1722	♀	138	183	25	18	32·8	18·2	11·7	5·0	8·7	17·3	5·5	6·1	2·8 × 1·8
1723	♀	128	172	25	18	30·8	17·9	9·8	5·3	8·5	16·0	5·3	6·0	2·8 × 1·7
1724	♀	120	180	24	18	30·5	17·7	11·1	4·9	8·4	16·1	5·4	6·3	3·0 × 1·8
1727	♀	127	184	24	17	30·6	18·1	11·4	5·9	8·5	16·5	5·5	6·2	2·8 × 1·7
1725	♂	—	—	—	—	—	18·0	11·0	5·7	8·8	17·0	5·2	6·5	3·0 × 1·7
1726	♀	—	—	—	—	31·6	17·3	11·1	5·2	8·6	16·6	5·8	6·0	2·8 × 1·7

Uromys anak Thomas

Uromys anak Thomas, 1907, *Ann. Mag. Nat. Hist.* **20:** 72.
Type locality: Ifogi, Brown River, NE. Papua, ± 4,000 ft.
Uromys rothschildi Thomas, 1912, *Nov. Zool.* **19:** 91.
Type locality: Rawlinson Mts., Huon Peninsula, New Guinea.

Nine specimens all from NE. New Guinea: ♂ 50.1227, ♀ 1228, Buntibasa district, Kratke Mts.; ♂ 1229, Kuraka, Kratke Mts.; ♀ 1232 skull only, Apimuri, Kratke Mts.; ♂ 1230, 1231, Saiko, Bubu River; ♂ 1676, juv. ♂ 1675, Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide; ♂ 1677, Menebe, 8 miles east Hagen Range, Sepik-Wahgi Divide.

Uromys caudimaculatus aruensis Gray

Uromys aruensis Gray, 1873, *Ann. Mag. Nat. Hist.* **12**: 418.
Type locality: Aru Islands.
Uromys validus Peters and Doria, 1881, *Ann. Mus. Stor. nat. Genova,* **36**: 703.
Type locality: Katau, mouth of Fly River, Papua.
Hapalotis papuanus Ramsay, 1883, *Proc. Linn. Soc., N.S.W.* **8**: 18.
Type locality: New Guinea.
Uromys nero Thomas, 1913, *Ann. Mag. Nat. Hist.* **12**: 208.
Type locality: Camp No. 3, Utakwa River, Dutch New Guinea, 2,500 ft.
Uromys scaphax Thomas, 1913, *Ann. Mag. Nat. Hist.* **12**: 209.
Type locality: Canoe Camp, lower Setakwa River, Dutch New Guinea, 150 ft.
Uromys prolixus Thomas, 1913, *Ann. Mag. Nat. Hist.* **12**: 213.
Type locality: Haveri, Astrolabe Range, Papua, 2,000 ft.
Uromys ductor Thomas, 1913, *Ann. Mag. Nat. Hist.* **12**: 213.
Type locality: Avera, Aroa River, Papua.
Uromys siebersi Thomas, 1923, *Treubia,* **3**: 422.
Type locality: Gunung Daab, Great Kei Island.

Nine specimens all from NE. New Guinea. Six from the Kratke Mts.: ♂ 50.1233, ♀ 1234, Buntibasa district; ♂ 1236, Apimuri; ♂ 1235, skull only 1238, Kambaidam; ♀ 1237, Sasara; and three ♂ 1678, 1679, 1680 from Degabaga, 8 miles east of Hagen Range, Sepik-Wahgi Divide.

Macruromys major Rümmler

Macruromys major Rümmler, 1935, *Z. Säugetierk.* **10**: 105.
Type locality: Buntibasa district, Kratke Mts., NE. New Guinea, 4,000–5,000 ft.

Three specimens, all from NE. New Guinea: ♂ 50.1249, Saiko, Bubu River; ♂ 1250, Yampara, Kratke Mts.; paratype ♀ 1251 skull only, Buntibasa district, Kratke Mts.

Lorentzimys alticola Tate & Archbold

Lorentzimys nouhuysii alticola Tate & Archbold, 1941, *Amer. Mus. Novit.,* No. 1101: 4.
Type locality: Nr. Lake Habema, Mt. Wilhelmina, Dutch New Guinea, 2,700 m.

Eleven specimens. Six from NE. New Guinea: ♀ 47.1295, Baiyanka, SE. Bismarck Range; ♂ 50.1730, ♀ 1732, juv. ♀ 1731, Yandara, high slopes Mt. Wilhelm; ♂ 50.1728, ♀ 1729, high northern slopes Mt. Wilhelm, Bismarck Range; and five in alcohol from eastern Papua: ♂ 47.1296, 1298, juv. ♂ 1297, ♀ 1299, ? 1300, Enaena, Mount Simpson.

The specimens from Baiyanka and Enaena were the first representatives of this genus to be received in London (Ellerman, 1949). The additional five specimens are very similar to these.

Parahydromys asper (Thomas)

Limnomys asper Thomas, 1906, *Ann. Mag. Nat. Hist.* **17**: 326.
Type locality: Mt. Gayata, Richardson Range, British New Guinea.
Parahydromys Poche, 1906 (June), *Zool. Anz.* **30**: 326 (to replace *Limnomys* Thomas).
Drosomys Thomas, 1906 (December), *Proc. Biol. Soc. Washington,* **19**: 199 (to replace *Limnomys* Thomas).

Fifteen specimens, all from NE. New Guinea: ♂ 50.1240, 1241, 1242, 1243, Buntibasa district, Kratke Mts.; ♂ 1244, 1245, Arau district, Kratke Mts.; juv. ♂ 1246,

1247 (skull only), Kuraka, Kratke Mts.; ♂ 1248, Saiko, Bubu River; ♂ 1669 (skin only), juv. ♀ 1670, Yanka, eastern slopes Hagen Range; juv. ♂ 1671, Menebe, 8 miles east Hagen Range, Sepik-Wahgi Divide; ♂ 1672, Degabaga, 8 miles east Hagen Range, Sepik-Wahgi Divide; ♀ 1673, [juv. ♀ 1674 in spirit], Tomba, SW. slopes Hagen Range.

Crossomys moncktoni Thomas

Crossomys moncktoni Thomas, 1907, *Ann. Mag. Nat. Hist.* **20:** 72.
Type locality: Serigina, Brown River, NE. Papua, 4,500 ft.

Fourteen specimens all from NE. New Guinea: ♂ 50.1239, Arau, Kratke Mts.; ♂ 1768, 1767, ♀ 1772, 1773, 1769, 1774, 1775, 1771, 1770, Baiyer River, east slope Hagen Range; ♂ 1776, Tomba, SW. slopes Hagen Range; ♂ 1777, ♀ 1778, 1779, Yandara, Bismarck Range. These are additional to the five specimens from Baiyanka mentioned by Ellerman (1949).

Leptomys elegans ernstmayri Rümmler

Leptomys ernstmayri Rümmler, 1932, *Das Aquarium* **6:** 131, 135.
Type locality: Ogeramnang, Saruwaged Mts., Huon Peninsula, NE. New Guinea.

Five specimens all from NE. New Guinea, ♂ 50.1252, 1254 (skull only), ♀ 1253, 1255 (skull only), Kambaidam, Kratke Mts.; ♂ 1256, Arau district, Kratke Mts.

Pseudohydromys murinus Rümmler

Pseudohydromys murinus Rümmler, 1934, *Z. Säugetierk.* **9:** 48.
Type locality: Morobe, Mt. Misim, NE. New Guinea, 7,000 ft.

Three specimens, all from NE. New Guinea: ♂ 50.1733, collector's No. 1136, Yandara, high slopes Mt. Wilhelm; ♀ 1734, collector's No. 1146, 1735, collector's No. 1151, high northern slopes Mt. Wilhelm, Bismarck Range.

These three specimens are new to our collection and appear to be the first specimens recorded since the type was described. The pelage agrees with the description of that of the type except that in No. 1734 it is a little shorter and greyer and in this same specimen the tip of the otherwise brown tail is white. The measurements also agree fairly well with those of the type and with the remeasurements by Tate (1951) which show that the length of the nasals is 8·0 mm. not 13.0 mm. as given by Rümmler.

These specimens extend the range of this species some 200 miles to the north-west of its type locality and to an altitude of 9,000–10,000 ft.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Condylo-basal length*	*Zygomatic breadth*	*Palatal length*	*Inter-orbital breadth*	*Diastema*	*Palatal foramina*	*Nasals, length*	m^{1-2}
50.1733	♂	88	91	19	9	22·8	10·6	11·0	4·7	5·7	2·1	7·7	3·1×1·1
1734	♀	103	91	20	10	—	10·8	11·3	4·5	6·0	2·1	8·0	2·8×0·9
1735	♀	105	93	19·5	12	22·9	10·6	11·1	4·8	5·7	2·0	—	3·2×1·1

Neohydromys gen.

This is a small mouse-like Hydromyine, not modified for aquatic habits. It is distinguished from all other Hydromyinae, including *Microhydromys* which Tate & Archbold (1941) described as the smallest known Hydromyine, by having much smaller molar teeth, which are $\frac{2}{2}$ as in most Hydromyinae, by its rather long muzzle which is short and broad in *Microhydromys* and by the large diastema which is larger than that of *Microhydromys*. The zygomatic plate is not so much excised in front as that of *Microhydromys*, and the upper incisor teeth are not grooved, a feature which appears to be unique to *Microhydromys*. The incisor teeth are, however, well developed and are slightly pro-odont, as are those of *Xeromys*. The bullae are rather similar to those of the type of *Microhydromys* (measurements of the type of *Microhydromys* are given in parentheses): width 2·9 mm. (2·9 mm.), length 4·0 mm. (3·8 mm.), distance apart 2·2 mm. (2.0 mm.). The palatal foramina are small as in *Pseudohydromys*, but the pterigoid and alisphenoid region is not swollen. The angular projection of the mandible is not so pronounced as in *Pseudohydromys*.

Type species: Neohydromys fuscus

Neohydromys fuscus sp. n.

Type locality: High northern slopes Mt. Wilhelm, Bismarck Range, NE. New Guinea, 9,000–10,000 ft.

Type: Adult ♀ 50.1736, collector's No. 1185, 19 June 1949. Skin and skull.

In external appearance this small murid is very similar to *Pseudohydromys murinus*. (I have not seen a specimen of *Microhydromys richardsoni* with which it also appears to be very similar in external appearance.) The pelage, which is about 4 mm. long, is smoky grey in colour and only slightly lighter ventrally. The ears are the same colour as the body. The fore and hind feet are slender and lightly covered with short white hairs. The tail is brownish both above and below; according to the collector the terminal 16 mm. was white; there are 17 rings of scales per centimetre, and the fine silvery scale hairs are only about half the length of the scale. The skull is a little larger than that of *Pseudohydromys murinus* but is easily distinguished from it by the very small molars, the slightly pro-odont incisor teeth (upper ones pale orange with white tips, lower ones pale yellow), the longer muzzle and larger diastema, and the less excised zygomatic plate. *Neohydromys fuscus* is also distinct from *Pseudohydromys occidentalis* Tate (1951).

Measurements in mm. (taken in the flesh):

Skin: head and body 92; tail 78; hind foot 21; ear 12.

Skull: condylo-basal length 24·3; zygomatic breadth 12·3; palatal length 13·1; inter-orbital breadth 5·2; diastema 8·2; palatal foramina 2·0; nasals (length) 7·9; bullae, 4·0×2·9; distance apart of bullae, 2·0; palatal breadth between m^1–m^1 2·6; length m^1+m^2 2·1; m^1 (length×breadth) 1·4×0·7; m^1 (length×breadth) 0·7×0·6; mandible, greatest length (except incisors), 13.4; m_1+m_2, 2·2.

CHIROPTERA

Pteropus sp.

One young ♂ 50.969 (skin only) from Fergusson Island.

Dobsonia moluccensis magna Thomas

Dobsonia magna Thomas, 1905, *Ann. Mag. Nat. Hist.* **16:** 423.
Type locality: Tamata, Mambaré River, eastern New Guinea.
Dobsonia moluccensis magna Thomas, Andersen, 1912, *Cat. Chiropt, Coll. Brit. Mus., 2nd ed.,* **1**. *Megachiroptera,* 825, *London.*

Two specimens, ♂ 50.1149, 1150, Buntibasa district, Kratke Mts., NE. New Guinea.

Nyctimene papuanus Andersen

Nyctimene papuanus Andersen, 1910, *Ann. Mag. Nat. Hist.* **6**: 621.
Type locality: Milne Bay, eastern tip of New Guinea.

One specimen ♂ 50.1153, Arau district, Kratke Mts., NE. New Guinea.

Paranyctimene raptor Tate

Paranyctimene raptor Tate, 1942, *Amer. Mus. Novit.*, No. 1204: 1.
Type locality: Oroville Camp, Fly River, Papua.

Two specimens collected 12 January 1933 which are new to our collection: ♂ 50.1151, ♀ 1152 from the Arau district, Kratke Mts., NE. New Guinea.

I have not been able to compare these specimens with the type but they appear to be very similar to the description of it; they have no dorsal stripe. Some of their measurements are a little larger but those for the teeth agree closely with those of the type.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Nasal tubes*	*Forearm*	*Lambda to gnathion*	*Orbit to nares*	*Zygomatic breadth*	*Inter-orbital breadth*	*Width brain-case*	*Palatal length*
50.1151	♂	77	19	—	10	4	55	25·2	4·5	16·2	4·2	10·7	12·9
1152	♀	80	20	—	10	4	55	—	4·5	16·2	5·0	11·0	—

Number	*Length upper canine from alveolus*	*Width upper canine at cingulum*	*Cingulum length of p^3*	*Height p^3 above alveolus*	*Cingulum length of p^4*	*Height p^4 above alveolus*	*Height lower canine above alveolus*	*Width lower canine at cingulum*	*Height p_3 above alveolus*	*Cingulum length of p_3*	*Height p_4 above alveolus*	*Cingulum length p_4*
50.1151	4·8	1·3	1·7	2·2	1·6	1·8	3·7	1·2	2·6	1·7	2·0	1·7
1152	4·7	1·3	1·7	2·2	1·6	1·5	3·8	1·3	2·5	1·7	2·0	1·7

Syconycteris crassa papuana (Matschie)

Macroglossus (*Syconycteris*) *papuanus* Matschie, 1899, *Die Fledermäuse des Berliner Museums f. Naturkunde, Megachiroptera:* 99. *Berlin.*
Type locality: Andai, NW. New Guinea.
Syconycteris crassa papuana (Matschie), Andersen, 1912, *Cat. Chiropt. Col. Brit. Mus., 2nd ed.,* **1**. *Megachiroptera,* 777, *London.*

Six specimens. Five from NE. New Guinea: ♂ 50.1798, 1799, Yandara, Bismarck Range, ♂ 970 [in spirit], Baiyanka, SE. Bismarck Range; ♀ 1800, Juzaing, Saruwaged Range, Huon Peninsula; ♂ 1801 [in spirit], Tomba, Hagen Range, and one juv. ♀ 971 [in spirit], from Enaena, NE. slopes Mt. Simpson, eastern Papua.

The spirit specimen from Tomba differs from the others by its narrow teeth, and it has less hair on the forearm than in the average specimens.

Hipposideros muscinus muscinus (Thomas & Doria)

Phyllorhina muscina Thomas & Doria, 1886, *Ann. Mus. Stor. nat. Genova,* **24**: 203.
Type locality: Fly River, Papua.
Hipposideros muscinus muscinus (Thomas & Doria), Tate, 1946, *Amer. Mus. Novit.,* No. 1323: 1–21.

Two specimens, ♂ 50.1154, ♀ 1155, Buntibasa district, Kratke Mts., NE. New Guinea.

Philetor rohui Thomas

Philetor rohui Thomas, 1902, *Ann. Mag. Nat. Hist.* **9**: 220.
Type locality: Albert Edward Range, Papua, 6,000 ft.

Seven specimens in spirit: ♂ 50.972, 973, ♀ 974, 975 976, 977, 978 from Enaena, NE. slopes Mt. Simpson, eastern Papua.

Pipistrellus collinus Thomas

Pipistrellus papuanus collinus Thomas, 1920, *Ann. Mag. Nat. Hist.* **9**: 533.
Type locality: Bihagi, head of Mambari River, Papua.
Pipistrellus collinus Thomas, Tate, 1942, *Bull. Amer. Mus. Nat. Hist.* **80**: 241.

One ♂ 50.983 [in spirit], Baiyanka, SE. Bismarck Range, NE. New Guinea.

Miniopterus schreibersi blepotis (Temminck)

Vespertilio blepotis Temminck, 1841, *Monographies de Mammalogie. . . .* **2**: 212. *Paris & Amsterdam.*
Type locality: Java—also Banda, Amboina, Timor, Japan.
Miniopterus schreibersii blepotis Temminck = *medius* = *ravus* = *eschscholtzii* = *fuscus* = *yayeyamae*) Tate, 1941, *Bull. Amer. Mus. Nat. Hist.* **78**: 567–597.

Two specimens, ♀ 50.1802, 1803 [in spirit], Tomba, Hagen Range, NE. New Guinea.

Miniopterus schreibersi magnater Sanborn

Miniopterus schreibersi magnater Sanborn, 1913, *Field Mus. Publ. Zool.* **18:** 26.
Type locality: Sepik River, New Guinea.

Three specimens, ♂ 50.1156, 1158, ♀ 1157, Arau district, Kratke Mts., NE. New Guinea.

Otomops secundus sp.n.*

Type locality: Tapu, Upper Ramu River Plateau, NE. New Guinea.
Type: Adult ♂ 50.982, collector's No. 568 [in spirit].
Paratypes: ♀ 50. 979, collector's No. 565, 980, collector's No. 566, 981, collector's No. 567. All in spirit (skulls extracted).

Since the recent (1948) discovery of the remarkable genus *Otomops* in New Guinea (*O. papuensis* Lawrence, type locality Vailala River, western Papua) these are the first additional specimens to be collected. While they are no doubt closely related to *O. papuensis*, their considerably longer forearm and well-marked pale mantle make it necessary to recognize them as distinct.

It is a small *Otomops* with all the distinctive external and cranial characters of the genus; with forearm 57 (type) and 58 mm. in length (49·2 in the type and only specimen of *O. papuensis*) and with broad pale buffy-grey mantle as in *O. wroughtoni* and other species. Colour: dark chocolate-brown on nape and lower back, darkest on lower back. Crown pale brown. Mantle across shoulders well defined, especially anteriorly, and consisting of pale buffy or greyish hairs of which only a few have dark tips. Along the margin of the membranes adjoining the body, above, there is a conspicuous but narrow white line composed of very short pure white hairs sharply outlining the deep chocolate of the body colour.

As in *O. papuensis*, the premaxillaries are open. Little importance should be attached to this feature, however, since in a series of eleven skulls of *O. wroughtoni*, type species of the genus, two have the premaxillaries separated, although their union was said by Thomas to be one of the generic characters. In the very deep basisphenoid pits and in the forward extension to the pterygoids of the tympanic bullae, as well as in the extension of the zygomatic plate, this new form presents (as Lawrence remarks of *O. papuensis*) characters of greater generic value than open or closed premaxillae.

Otomops secundus differs from *O. formosus* Chasen of Java in much smaller skull, 21·2 (against 24), although the forearm measurements of the two forms are closely approximate (59·7 in *O. formosus*). Although the forearm in *O. secundus* is nearly 10 mm. longer than in *O. papuensis*, the cranial measurements show little difference. The type locality of the new form is little more than 100 miles north of that of *O. papuensis*, but is separated from it by the central mountain range. It is possible that further collecting in New Guinea and other parts of the Indo-Australasian Archipelago may eventually bring to light intermediate forms and so reduce to

* The description of this species is by Mr. R. W. Hayman.

subspecific rank some of the named species; but until then it seems advisable to separate specifically the present form.

Measurements in mm. (External from spirit specimens: type of *O. papuensis* in parentheses):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Hind foot and tibia*	*Ear*	*Forearm*	*Total length skull*	*Condylo-basal length*
50.982 Type	♂	71 (67)	37 (30)	10 (10·6)	23·9 (23·5)	24 (22·2)	58 (49·2)	21·2 (20·2)	19·3
979	♀	68	38	10	22·0	24·3	58	21·0	19·9
980	♀	70	36	10	24·9	24	57	21·5	19·8
981	♀	68	33	10	24·6	23	58	21·0	19·5

Number	*Zygomatic breadth*	*Width braincase*	*Bulla to top of braincase*	*Lower jaw*	*Breadth across canines*	m^3–m^3	i–m^3	c–m^3	c–m_3
50.982 Type	11·2	10·9 (9·5)	9·9 (9·9)	13·1	4·5	8·0	8·6 (8·5)	7·5	8·0 (7·7)
979	11·1	11·2	9·9	14·0	4·2	8·0	8·7	7·6	8·1
980	11·0	11·0	9·9	14·0	4·4	8·0	8·7	7·8	8·2
981	—	10·9	10·1	13·7	4·4	8·0	8·7	7·8	8·0

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APPENDIX I

LIST OF LOCALITIES FROM WHICH SPECIMENS WERE OBTAINED

North-East New Guinea

Apimuri (Buntibasa district), Kratke Mts., 4,500 ft.
Arau district, Kratke Mts., 4,000–5,500 ft.
Baiyanka, Purari-Ramu Divide, SE. Bismarck Range, 7,500–8,500 ft.
Baiyer River, nr. Yanka, east slopes Hagen Range, Central Highlands, 8,000 ft.
Binemarian, Kratke Mts., 4,000–5,000 ft.
Bogo, 50 miles east of Hagen Government Station, south slopes Bismarck Range, 6,000 ft.
Bubu River district (Upper Waria River), 5,000–8,000 ft.
Buntibasa district, Kratke Mts., 4,000–5,500 ft.
Degabaga, 8 miles east of Hagen Range, 25 miles north of Hagen Govt. Station, Sepik-Wahgi Divide, Central Highlands, 4,500–6,000 ft.
Garaina, Upper Waria River, 2,500–3,000 ft.
Guyebi, northern slopes Mt. Wilhelm, Bismarck Range, 6,000–7,000 ft.
Herowagi (42 miles east of Hagen Govt. Station), south slopes Bismarck Range, 7,000 ft.
High slopes Mt. Wilhelm, Bismarck Range, 9,000–10,000 ft.
Junzaing, Saruwaged Range, Huon Peninsula, 6,000 ft.
Kambaidam (Buntibasa district), Kratke Mts., 4,000 ft.
Kuraka (Buntibasa district), Kratke Mts., 4,000–5,000 ft.
Menebe, 8 miles east of Hagen Range, 20 miles north of Hagen Govt. Station, Sepik-Wahgi Divide, Central Highlands, 4,500–5,500 ft.
Mendi, northern slopes Mt. Wilhelm, Bismarck Range, 4,500 ft.
Saiko, Bubu River (Upper Waria River), 5,000–7,000 ft.
Sasara (Buntibasa district), Kratke Mts., 4,500–5,500 ft
South and north side Bubu River (Upper Waria River), 6,000–7,000 ft.
Tapu, Upper Ramu River Plateau, 6,000 ft.
Tomba, south-west slopes Hagen Range, Central Highlands, 8,000–9,500 ft.
Yampara (Buntibasa district), Kratke Mts., 4,700 ft.
Yandara, northern slopes Mt. Wilhelm, Bismarck Range, 5,500–10,000 ft.
Yanka, eastern slopes Hagen Range, Central Highlands, 5,000–8,000 ft.
Zageheme, Cromwell Mts., Huon Peninsula.

Eastern Papua, South-East New Guinea

Bibitau, Mt. Orian (30 miles NW. Mt. Simpson), Main Range, 2,500 ft.
(Boneno Camp), Mt. Maneao (35 miles NW. Mt. Simpson), Main Range, 6,000 ft.
Boneno, Mt. Mura (30 miles NW. Mt. Simpson), *c.* 4,000–7,000 ft.
Enaena, NE. slopes Mt. Simpson, 1,000–6,500 ft.
Ikara, NE. slopes Mt. Simpson, 3,500–5,000 ft.
Maneao Range (35 miles NE. Mt. Simpson), 7,000 ft.
Mt. Mura (30 miles NW. Mt. Simpson), Main Range, 5,000 ft.
Wapona, north slopes Maneao Range (35 miles NW. Mt. Simpson), 1,000 ft.

Other Localities

Faralulu district, West Fergusson Island, SE. New Guinea, 600 ft.
Taibutu district, West Fergusson Island, SE. New Guinea, 900–1,100 ft.
Mountains above Taibutu village, West Fergusson Island, SE. New Guinea, 2,000–3,000 ft.
Lau, Bainings Mts., Gazelle Peninsula, New Britain, 1,300 ft. (*Rattus exulans browni* only.)
Mountains SE. New Guinea, behind island of Samaria.
Tongoa Island, New Hebrides, 400 ft. (*Rattus exulans exulans* only.)

APPENDIX II

FORMS DESCRIBED AS NEW IN THIS PAPER

Zaglossus bubuensis
Dactylopsila tatei
Pseudocheirus (*Pseudochirops*) *corinnae fuscus*
Peroryctes longicauda magna
Peroryctes papuensis
Murexia longicaudata parva
Antechinus hageni
Pogonomys fergussoniensis
Pogonomys shawmayeri
Rattus ruber fergussoniensis
Rattus verecundus tomba
Neohydromys fuscus (new genus)
Otomops secundus

APPENDIX III

Dendrolagus dorianus notatus Matschie

Dendrolagus notatus Matschie, 1916, *Mitt. zool. Mus. Berlin*, **8**: 294.

Type locality: Slopes of the Schrader Mountains, between 5° S. and 144° E., NE. New Guinea.

Two specimens, a young adult ♂ 50.1815 and a juv. ♀ 1816 from Yanka, eastern slopes Hagen Range, 8,000 ft.

These specimens were collected about 30 miles away from the type locality and appear to be the first to be recorded since the type was described from a single specimen.

Measurements in mm. (taken in the flesh):

Number	*Sex*	*Head and body*	*Tail*	*Hind foot*	*Ear*	*Basal l ngth*	*Zyg matic breadth*	*Nasals*	m^{1-3}	p^4	m^1	m^2	m^3	m^4
50.1815	♂	610	470	108	50	165·5	66·2	41·8 × 21·0	13·8	10·6 × 6·0	7·0 × 6·1	7·0 × 6·6	6·8 × 6·6	6·5 × 6·3

PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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BULLETIN OF
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ZOOLOGY Vol. 1 No. 11
LONDON: 1953

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X vf.

Pp. 319–350; *Pls.* 36–38; 5 *Text-figures*

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series, corresponding to the Departments of the Museum.*

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This paper is Vol. 1, No. 11 of the Zoological series.

PRINTED BY ORDER OF THE TRUSTEES OF THE BRITISH MUSEUM

Issued January 1953 *Price Ten Shillings*

TAXONOMY OF THE KARROO AND RED-BACK LARKS OF WESTERN SOUTH AFRICA

By J. D. MACDONALD

[Received 1st September 1951]

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SYNOPSIS

A review of the Karroo and Red-back Larks in the light of recent data indicates that these two birds, long regarded as separate species, and sometimes placed in different genera, are in fact geographical races of the same species. Variation is limited almost entirely to colour and pattern, and there is a gradual transition from one extreme form to another. Seven geographical races are recognized, two of which are new.

INTRODUCTION

MATERIAL and data collected by the British Museum (Natural History) South West Africa Expedition (1949–1950) throw new light on the taxonomy of the Karroo and Red-back Larks, usually assigned to the genera *Calendulauda* and *Pseudammomanes*. Birds of two different colours, apparently identical in every other respect, were found in each other's company near the mouth of the Orange River. The 'grey' birds were thought to be *Calendulauda albescens* and the 'red' birds *Pseudammomanes* (?species). It now seems that these birds belong to two groups which may be more closely related than has been recognized hitherto. The purpose of this paper is to examine this matter in the light of the data now available.

HISTORICAL NOTE

The published history of these larks begins with the description of the Karroo Lark by Lafresnaye[1] (1839:259). He described two species, first *Alauda albescens*

[1] The name *Certhilauda nivosa* Swainson, 1837, though often used for the Karroo Lark, was shown by Roberts (1936*a*: 257) to be inapplicable, being based on a juvenile *Galerida cristata senegalensis*.

from Blauw-Berg (Blaauwberg Beach, in the north of Table Bay), a 'grey' bird, and then a 'red' species *A. guttata* from Elephant's River (now Oliphant's River), Cape Province. The types are in the Museum of Comparative Zoology, Cambridge, Mass., U.S.A.: that of *A. guttata* is said to be a bird in juvenile plumage. Unaware of Lafresnaye's description Andrew Smith (1843) also described 'grey' and 'red' birds as separate species, the former as *Alauda codea* and the latter as *A. lagepa*, both of which were figured together on Plate 87. Specimens of each of his species are represented in the National Collection, but they can only be regarded as co-types, for Smith did not designate types and his collection was split up.

An analysis of Smith's descriptions shows that in dimensions, distribution, and habits these two species are very similar. Sharpe (1874: 624) came to the conclusion 'that they are nothing but the summer and winter plumage of the same bird. However curious this may seem, I think it is not to be refuted on the evidence of the specimens which I have before me'.

Sharpe's opinion held until Roberts (1936*a*: 258; 1940: 191) revived the conception of two sympatric species differing mainly in colour and divisible into several geographical races. In the pallid or grey form, *Calendulauda albescens*, he recognized three races, the typical one, a second race *C. a. saldanhae*, with a strong tinge of rufous on the upper parts, but not so rufous as *C. guttata*, and a third *C. a. karruensis*, very dark above with some rufous in parts. In the rufous form, *C. guttata*, he recognized two races, *C. g. calviniensis* being slightly larger than the typical form.

Meinertzhagen[1] (1951: 107) put all these variations into one polymorphic species, *C. albescens*, in which variation could not be correlated with distribution. He calls it 'a very variable bird in both size and colour throughout its range. It has a pure grey and a pure red phase, with every intermediate and without constancy in distribution'.

The first Red-back Larks were found by Andersson in the dry sandy bed of the Kuiseb River, near Walvis Bay. Strickland (1852) named them *Alauda erythrochlamys*. Several birds found in other localities, notably in the Transvaal by Ayres (1874), were wrongly associated with this species, but remained with it until removed by Roberts. In fact the true Red-back Lark does not seem to have been recorded[2] again until Roberts (1937: 95) found it about 30 miles north of Aus, a place about 60 miles inland from Luderitz Bay and about 300 miles south of Walvis Bay. Roberts also found specimens nearer Aus, but concluded that they belonged to a different species, which he named *Pseudammomanes barlowi*.

Hoesch and Niethammer (1940: 224) did not agree with Roberts and maintained that the Aus birds were inseparable from those at Walvis Bay. Neither did Meinertzhagen (1951: 107), but he put the species into the genus *Certhilauda* along with the Karroo Lark and several other species.

[1] I am indebted to Colonel R. Meinertzhagen for his courtesy in lending me a typescript copy of his paper which was in course of publication when this paper was in preparation.

[2] R. D. Bradfield collected a specimen on the Kuiseb River on the 18th of December 1928, but it does not seem to have been recorded. It is in the Transvaal Museum.

METHODS

The morphological characters examined here are lengths of wing, tail, bill, and first primary; also colour and colour-pattern. Other characters considered are moults, breeding-cycle, developmental stages, and habits.

Wing measurements are taken on the stretched wing; tail measurements from the crotch of the two central tail feathers, into which the leg of a divider can be firmly pressed, to the tip of the longest feather; bills are measured from the cranio-facial angle to the tip; and first primary from the hard sheath covering the base of the shaft. The degree of error due to the set of the wing, the variation in the method of stretching, and the age of the critical feathers, whether fresh or not quite fully grown, or in various stages of wear, made it impossible to attempt extremely accurate measurements. The purpose of the measurements is merely to discover general correlations and they are taken to the nearest millimetre.

For standards of colour Villalobos's *Colour Atlas* (1947) was used. This atlas contains a range of thirty-eight hues each of which is divided into a number of tones obtained by the combination of two variables, degree of lightness and degree of chromaticity. For example, in the symbol OOS/12/5 the OOS indicates the hue which is a mixture of two parts orange and one part scarlet; the figure 12 indicates the degree of lightness, the range 1–20 being from darkest to lightest; and the figure 5 the degree of chromaticity, the range 1–12 being from the least to the greatest intensity of colour. Even without the *Colour Atlas* these symbols can convey some meaning to the reader, at least in a comparative sense. For example, of the differently coloured larks of this group under examination from near the mouth of the Orange River the 'grey' birds match approximately OOS/9/4 and the 'red' birds OOS/8/5; the inference is that they belong to the same colour group, or hue, but that the 'grey' birds are one degree lighter and one degree less colourful than the 'red' birds.

The use of these symbols may be regarded as an experiment in this method of colour determintation and colour comparison. The conclusions reached so far is that, though it is not ideal, it is unquestionably more satisfactory than the usual descriptive terminology, which often means one thing to the writer and something quite different to the reader. The *Colour Atlas* gives a cross-reference to colour names in common use, and where possible these have been included in the text. In birds with a streaked pattern the coloured area referred to in the following notes is that found outside the dark centres of the feathers (see Fig. 4).

MATERIALS AND ACKNOWLEDGEMENTS

This study is based on 80 specimens collected by the British Museum (Natural History) South West Africa Expedition (1949–1950), 36 other specimens in the National Collection, 45 in the Transvaal Museum, Pretoria, 13 in the South African Museum, Cape Town, and 21 in the private collection of Colonel R. Meinertzhagen.

For their kindness in giving me permission to examine specimens, and sending others to me for examination, I have to thank Dr. V. FitzSimons and Mrs. J. Campbell, of the Transvaal Museum; Dr. K. Barnard, of the South African Museum; and Colonel R. Meinertzhagen.

I am indebted to Mr. J. D. M. Keet, of the Department of Agriculture, Pretoria, for information on the *Aristida* grasses of the Namib. For obtaining permission to enter the diamond controlled area at Tsondab Mund to look for these larks I am indebted to Mr. A. D. Vos, Inspector of Mines, Windhoek; and to Colonel Mentz, of the South African Police, for providing us with a police escort.

Many of the specimens and data obtained by the Expedition were collected by two of my companions, Colonel F. O. Cave and Mrs. B. P. Hall. As a small tribute to their assistance, two new geographical races, based on material collected by the expedition, have been named after them.

POPULATIONS EXAMINED

In the first instance the evidence of specimens in various localities and areas will be examined: these places are located on the map, Plate 36. It is convenient to begin with the Cape area.

Cape Flats

Eleven specimens from localities in the Cape Flats have been examined. They are from Blaauwberg, on the coast about 10 miles north of Cape Town, the type locality of *Alauda albescens*; Milverton, a few miles north of Blaauwberg; Durbanville, about 10 miles out of Cape Town on the Wellington road; and Philadelphia, about 20 miles out on the Malmesbury road. There is also an old Butler specimen labelled 'Cape Town'. All these birds are similarly 'grey' in colour, actually a light drab, about OOS/11/3 in the *Colour Atlas*. Birds of this colour have not been recorded from localities outside the Cape Flats, other than 'grey' birds of a slightly different tone which occur along the coast (see notes on Berg River and Saldanha Bay specimens). But three Smith specimens which are identical and belong to his 'grey' *A. codea* require a special note, for Smith (1843) gives the range of this species as 'generally found upon the Karroo plains between the Oliphant and Orange Rivers'. Roberts (1936*a*: 312) shows that Smith had made entries in his early diaries on a lark found in the vicinity of Cape Town which, as Roberts points out, might easily have been this species. When he prepared his *Zoology* some years later, Smith must have had some difficulty in sorting out his data referable to birds he then described as the new species, *A. codea* and *A. guttata*, especially as these birds now appear to be polychromatic variations of the same species. It is my opinion, therefore, that Smith actually obtained the specimens on which he based his *A. codea* in the Cape area and not between the Oliphant's and Orange rivers.

One of Smith's specimens is just completing moult. It is undated, but may be the specimen referred to by Smith in his notes, see Roberts (1936*b*: 313), 'on the 4 December killed a young lark . . . on the ascent of the Lions Rump'.

According to A. W. Vincent (1946: 446) 'they begin to show breeding activity in early August'; he has seen young birds about in October, but also nests with eggs in November. He says that this lark 'appears to be confined to the lower shady ground to the northward along the coast and close to the shores, becoming common farther out and extending through the drier western districts'.

The dimensions of the fourteen specimens referred to are as follows:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	5	88–94	62–68	18–20	28–32
♀	4	82–88	56–61	18–20	28–33
?	5	85–90	60–64	17–19	27–33

The Cape Flats population, therefore, seem to have a distinctive light drab colour and the small range of measurement shows that females are slightly smaller than males. The main breeding-period appears to be about September to November, and the usual habitat is sandy scrub.

Berg River and Saldanha Bay

One Layard specimen from Berg River matches the Cape specimens perfectly in colour. Two other Layard specimens from the same locality have a slight pinkish-rufous wash on the upper parts, about OOS/10/3. All are undated and only one is sexed. Modern maps show Berg River as a locality about 70 miles north of Cape Town and about 15 miles from the mouth of the Great Berg River which opens into St. Helena Bay. On old maps the river itself is so named and there is therefore no certainty that the specimens were collected in exactly the same locality.

Roberts (1936*a*: 258) found rufous-coloured birds at Saldanha Bay, which is on the coast about 20 miles west of Berg River and 60 miles north of Cape Town. He described them as having 'a strong wash of rufous on all the upper parts, but not as rufous as in *Calendulauda guttata*'. Two specimens collected by Shortridge in 1903 at Hoetzes Bay, Saldanha Bay, which are in the South African Museum, fit this description and are exactly similar to our pinkish-rufous Berg River specimens. They are rather worn. One of Roberts's specimens, collected in November, is in juvenile plumage.

Measurements of Berg River and Saldanha Bay specimens are as follows:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	3	91	62–68	19–20	31–32
♀	1	88	61	20	27
?	2	90–93	64–66	20	28

There is, therefore, evidence suggesting that the Cape Flats population extends north to some locality on the Great Berg River and is there replaced by populations which are mainly pinkish-rufous, the latter not showing any appreciable dimensional difference nor difference in breeding-period.

Lambert's Bay

Three specimens, an adult and two juveniles, from Lambert's Bay, about 130 miles north of Cape Town, are in the Transvaal Museum. The adult is slightly more colourful, about OOS/10/4, than the Saldanha Bay birds, and similar specimens

collected by Roberts from near Port Nolloth, which he associated with his *C. a. saldanhae*: its dimensions are, wing 92, tail 71, bill 19. The juveniles taken in October are more richly coloured, about OOS/10/5, and compare with inland specimens from Klaver and Springbok areas. The material is too scanty on which to base any conclusions, but it seems that 'greyish' birds somewhat similar to those at Saldanha Bay do occur on the coast at this point, and may connect with similar populations which have been found farther north at Port Nolloth.

Swellendam and Deelfontein

Before going inland, across the mountains, to Klaver, Van Rhynsdorp, and north to the Springbok area, specimens from east and north-east of Cape Town may be examined.

A Layard specimen from Swellendam, which is about 150 miles due east of Cape Town and 30 miles inland, is snuff-brown, about OOS/6/5. It is in very fresh plumage, but is neither dated nor sexed: dimensions are, wing 83, tail 62, bill 18, first primary 30. A rather lighter tone of colour, about OOS/7/5, is found in two adult specimens from Deelfontein, which is about 280 miles to the north-east of Cape Town and about 25 miles from De Aar where Roberts (1936*a*: 258) located his *C. a. kurruensis*, which was described as 'a very dark race'. One juvenile from the same locality, with wings and tail half-grown, is rather richer in colour, about OOS/6/7, while a second juvenile is noticeably browner, about OOS/9/5, and in this respect is very like birds in juvenile plumage from the Springbok area. The two adults were in fresh post-breeding plumage when taken in late February, which fits in more or less to the same breeding-cycle of the juvenile of the same colour taken in early March. The browner juvenile was taken in late January, and from the worn condition of its plumage had been in this dress for about 2–3 months. Dimensions are:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	1	94	69	?	28
♀	1	84	62	16	26
Juv. ♂	1	92	66	15	29
Juv. ♀	1	?	?	?	?

Apart from one specimen which does not fit in colour, nor apparently in breeding-cycle, the Swellendam and Deelfontein specimens, in colour at least, are similar. They are distinctly different from those in the areas so far examined, but appear to be not unlike birds in the Springbok area.

Traka and Nels Poort

Traka and Nels Poort are about 60 miles north and south of each other, and about 250 miles east of Cape Town. Single Layard specimens from each of these localities are very similar in colour, but are rather duller brown than the Swellendam–Deelfontein specimens. In the Traka and Nels Poort birds the lighter outer area of the feathers is almost entirely replaced by the darker centre which is dark brown, about OOS/6/4. The thin margin of lighter colour is about OOS/9/5, and the juvenile

has almost pure white tips and margins. They are neither sexed nor dated. Dimensions are:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
?	1	92	64	17	26 (Nels Poort)
?	1	91	68	?	34 (Traka)

Namaqua–Bushman-land Region

Specimens from Klaver, on the Oliphant's River, and van Rhynsdorp, east to Calvinia and Carnarvon, and north to Kamieskroon, Grootberg,[1] Springbok, and the majority of those obtained near Port Nolloth are very alike in general colour, and will be considered together. A series of 63 specimens, largely from the Springbok area, have been examined. On the whole they seem to be a shade lighter than the Swellenden and Deelfontein specimens, being about OOS/8/5 as against OOS/6/5; the outer margins of the feathers are lighter, almost whitish in fresh specimens—particularly on the wing converts—and the dark central streaks are rather narrower and less diffuse. Below, the general colour is whiter, lacking much of the creamy-buff wash, which is particularly evident on the breast.

A series of adults taken at different times of the year provides information on seasonal changes. Three males collected by Gill at Kamieskroon in September had enlarged gonads; they are very worn, and were almost certainly breeding. Specimens collected by us in the same locality in early December are just beginning post-breeding moult; others from Klipfontein later in the month are just completing moult. Moult apparently begins on forehead and throat and works backwards towards the tail. Wing coverts are moulted early, but wing and tail moult begins later and in the usual manner, namely, starting at the junction of primaries and secondaries in the wing and proceeding away from that position, and commencing with the central pair of tail feathers. Specimens sometimes are in very fresh body plumage when wings and tail are barely half moulted. New feathers on the upper parts have a pinkish 'bloom' and have a very pale, nearly white edge on wing coverts, scapulars, and inner secondaries. During the year feathers become very much abraided, the pinkish 'bloom' disappears, pale edges disappear, and inner secondaries and central tail feathers in particular become very much worn.

Young birds in juvenile plumage were more in evidence at Kamieskroon and Springbok early in December when adults were beginning to moult. None was found at Klipfontein later in the month when adults had nearly completed moult. (Young birds in this area were not specially sought.) The main feature of the juvenile plumage is that the dark centres of the feathers are much narrower, sometimes

[1] An Andersson locality. Wallis (1936: 285), in his biography of Andersson, notes that 'on July 2nd (1862) Andersson came to the ford of the Orange River (Sendelings Drift)'. After sending his wife and child ahead in the waggon 'he was able to rejoin them about the middle of July near the Buffalo River in Cape Colony'. He must therefore have been a good way south of Grootberg on the Orange River by the 29th July, the day on which the specimens were collected. The Buffalo River is presumably the one now named on maps as Buffel's River, which rises in the mountains south of Springbok. On some large-scale maps there is a locality marked Grootberg, about 13 miles south-west of Kamieskroon, and it is almost certain that this is the locality in which the specimens were collected.

almost completely absent on the body feathers of the back, but when present appear as black flecks rather than streaks. On the innermost secondaries the dark streaks are very little wider than the shaft, and in the central tail feathers it is only about half as wide as in adults. Whitish tips to body feathers are broad and produce a speckly appearance. The pinkish 'bloom' found in adults is lacking and because the dark feather centres are smaller the general effect is of a lighter and browner bird, although in fact the tone is very little different, about OOS/9/6.

Seasonal change, mainly due to abrasion, is evident; the worn plumage is appreciably duller. Four specimens, however, from widely scattered localities are rather lighter and browner in tone, about midway between true juvenile and adult. This difference may indicate a developmental variation, a distinctive first adult dress for example, or it may be an index of individual variation.

Samples of population from the coastal plains around Port Nolloth show a high percentage of 'grey' phase birds. Roberts made a very interesting sectional picture of the population in this area when he collected between Klipfontein and Port Nolloth. Although his data suggests that 'grey' birds were limited to a narrow coastal belt about 25 miles in width (see Table below), there are three specimens of 'red' birds in the National Collection which were obtained at Port Nolloth: two by Charles Reid in 1902 and one by C. H. B. Grant in 1903. Also out of six specimens collected by Meinertzhagen on the Klipfontein escarpment, about 45 miles inland, one is a 'grey' bird. Meinertzhagen's specimen is the farthest inland record of the 'grey' phase.

No.	*Locality*	*Date*	*Colour*
766	Klipfontein	17.8.37	'Red'
798	25 miles east of P.N.	19.8.37	
800	,, ,,	,,	
801	,, ,,	,,	
802	,, ,,	,,	
808	Port Nolloth	,,	'Grey'
809	,,	,,	
811	,,	,,	
822	,,	20.8.37	
841*	25 miles east of P.N.	,,	
836	,, ,,	21.8.37	'Red'
840	,, ,,	22.8.37	

* Date suggests that this number should be 831.

Dimensions of 63 specimens from this region, including 'grey' birds from the coastal plains, are as follows:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	38	86–100	62–74	17–20	28–36
♀	21	84–93	58–67	16–20	26–32
Juv. ♂	2	89–91	70–74	17	28–32
Juv. ♀	1	86	64	18	32
?*	1	90	65	19	28

* Smith specimen: co-type of his *Alauda lagepa*.

Birds from this region have a higher degree of chromaticity than those in the Cape, Berg River, and Lambert's Bay areas; they are nearest to the Swellendam and Deelfontein specimens, but a shade lighter in tone, with a slight narrowing of the dark feather centres and a purer white on under parts. There is an obvious difference between juvenile and adult plumages due mainly to a great reduction in the width of the dark feather centres in juvenile feathers and the lack of pinkish 'bloom', typical of adults in fresh plumage. There is an indication that there may be an intermediate plumage between juvenile and full adult, and that coastal populations in the Port Nolloth area consist predominantly of 'grey' phase birds. These latter are somewhat similar in appearance to those found farther south at Lambert's Bay and Saldanha Bay. There is a large enough sample to show that females are slightly smaller than males and that the smaller samples from other areas fit into the range of measurements for this region.

Orange River Mouth

The Karroo Lark populations so far examined are readily linked together by similar dimensions and plumage pattern. (The significance of the colour difference will be discussed later.) Immediately to the north-west of these populations, near the mouth of the Orange River, there are birds which appear to be geographical representatives of the Karroo Lark in which the dark streaks in the pattern are considerably reduced with a consequently higher proportion of the more brightly coloured areas (see Plate 37). It is not known exactly where the change takes place and how it is effected. There is no obvious sudden change in the character of the country, which consists of monotonous rolling tracts of low scrub which gradually thin out to almost pure desert near the Orange River. The change was first observed in a specimen collected by the British Museum Expedition along the coast 38 miles north of Port Nolloth and a few miles south of the Orange River. The difference lies almost entirely in reduction in the width of the dark centres of the feathers. In the body feathers of the upper parts dark centres have almost completely disappeared, or are reduced to a thin and rather diffuse dark streak of the same general colour on the rest of the feather. Streaking on the breast is slightly reduced and is absent on flanks and belly. There is very little change in the pattern of wing and tail feathers.

The specimen mentioned above, and six others collected at Grootderm, about 14 miles up the Orange River, belong to the 'grey' group, while two others belong to the 'red' group. The 'red' tone is almost identical with that found in Springbok birds, about OOS/8/5, while the 'grey' tone is about OOS/9/4 and almost identical with Robert's 'grey' specimens from near Port Nolloth. Both the 'red' specimens were found in the company of 'grey' birds, and all are in the process of total moult. Three other specimens were found in the Transvaal Museum which had been collected in 1942 at Orange Mouth. They are 'grey' birds, matching our specimens, except that they are stained with red soil or sand. Taken in September they must have been breeding. Dimensions of the twelve specimens are as follows:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂ R.	2	86–89	63–67	20–21	28–30
♂ G.	6	86–96*	63–68	20–21	26–30
♀ G.	4	82–87	61–64	17–19	26–27

R. = 'red' phase. G. = 'grey' phase.
* Next smallest are two specimens at 92.

Important points to note about these Orange River specimens are that reduction in the amount of streaking is the only apparent difference from specimens in the Port Nolloth and Springbok areas, and that in the narrow coastal belt birds are predominantly 'grey'. If the streaks were reduced to the point of disappearance the effect would be the appearance of the Red-back Larks which belong to regions north of the Orange River. Another connecting link between Karroo and Red-back larks is found in specimens from the next area to be considered.

Witputs Area

Witputs, a lonely police outpost, lies about 60 to 70 miles due north of Grootderm and at the southern tip of the Huib Plateau. A series of eighteen specimens was obtained there in late January. Environmental conditions were very similar to those in which the Karroo Lark lived in Little Namaqualand—namely, low sparse scrub mixed with prostrate succulents (see Plate 38*a*). Although taken a month later than the Grootderm specimens the adults, of which there are thirteen, are only just completing moult. The adult plumage is darker and richer in colour than the 'red' Grootderm specimen, about OOS/7/6 (cinnamon-brown) as against OOS/8/5.

Dark centres to body feathers of the upper parts have almost completely disappeared, although in occasional specimens—one out of the thirteen collected—the markings are rather more distinct and comparable with the Grootderm specimens (see Plate 37). There is also an appreciable narrowing in the dark centres on the inner secondaries and central tail feathers. Little change is noticeable on the under parts except that the white is inclined to have a slight buffish tint. The worn breeding plumage is not represented.

The five young birds are in moult and illustrate the transition from juvenile to first adult plumage. The moult appears to be a partial one, for there is no indication of wing and tail feathers being shed. Body moult proceeds in an anterior-posterior sequence. The difference in colour-tone between the two plumage phases is very apparent: the juvenile is a pale brown, about OOS/9/5, contrasting strongly with the OOS/7/6 of the fresh adult feathers. Interesting features are the reduction in the width of the dark centres of the central tail feathers and the increase in the width of the pinkish margins on the inner webs of the inner wing feathers. Dimensions are as follows:

Sex		*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
Ad.	♂	6	92–96	69–71	20–21	29–32
	♀	7	83–87	59–64	17–18	26–28
Juv.	♂	2	89–91	65–72	20	26–29
	♀	3	78–84	61–65	17	26–30

Although the Witputs birds are clearly different to those at Grootderm, they are obviously related, for the differences are only slight quantitative changes.

Aus Area

Aus is a small village about 80 miles north of Witputs, about 60 miles inland from Luderitz Bay, and on the Namib Desert side of the main backbone range of mountains. It is easily reached by road or rail and has been a collecting centre for a number of ornithologists. Red-back larks in this area have given rise to some controversy.

Roberts (1937: 88) reported that whilst delayed by a mechanical breakdown about 30 miles north of Aus, on the Helmeringhausen road, he collected a series of larks which he claimed to be identical with *Pseudammomanes erythrochlamys* (Strickland) from Walvis Bay. Subsequently he camped 'in the flats below the hills to the west of Aus', where he obtained a further series of Red-back larks. These he considered were different from *P. erythrochlamys* 'in having the inner lining of the wing-quills with only a trace of pinkish on the inner edges—not broadly pinkish—and the middle tail feathers above with a broad central stripe of dark greyish-brown; the outer tail feathers are also on the whole darker, only the outer web of the outermost being pinky-whitish, the rest of the feather blackish with only the tip pale; the outer webs of the primaries above is only very thinly or not at all pinkish'. He also gives the following dimensional differences:

Sex		*No.*	*Wing*	*Tail*	*Tarsus*	*Culmen*
P. barlowi	♂	7	93–97	68–72	24·5–26	18–19
	♀	2	83–87	61·5–64	24·5–26	16–16·5
P. erythrochlamys	♂	8	89–95	67–74	26–28	17–18·5
	♀	5	84–85	64–69	24–26	14·5–16

He considered that these were sufficient criteria for the recognition of a new species and gave them the name *P. barlowi*.

Hoesch and Niethammer (1940: 60) visited Aus in late December and early January 1938–1939. Red-back larks were collected only on the farm of Kubub, which is about 2–3 miles south of Aus, except for one found about 30 miles farther west, at Tschaukaib, on the road to Luderitz Bay (see Fig. 1.) On the evidence of these specimens they disagreed with Roberts, stating that the dark stripe in the central tail feathers is variable, and put his *P. barlowi* into the synonymy of *P. erythrochlamys*. They do not record that they had either found or examined typical specimens of *P. erythrochlamys*. Roberts had this advantage, for there was a specimen from the Kuiseb River in the Transvaal Museum collected in December 1928 by R. D. Bradfield.[1]

It is almost certain that Roberts would have made his points clearer in the fuller account which he proposed to publish, for the important factor correlated with the difference he observed is the occurrence of large tracts of shifting sand-dunes. In his preliminary account the only clues he gives are that the birds 30 miles north of

[1] Incidently, Roberts collected two specimens at Rooibank, 30 miles up the Kuiseb River, in September 1941: he did not have an opportunity to comment on them in print.

Aus were 'found in large numbers on some dunes, but not in the plain near by', while of those west of Aus he merely states they were 'on sandy dunes'. Details of the area in the vicinity of Aus are shown on the accompanying sketch map.

To the north of Aus the dry-bed of the Koichab River forms the southern boundary of an immense area of sand-dunes which stretches for about 200 miles northwards to Walvis Bay at an average depth of about 70 miles from the coast. The Helmering-

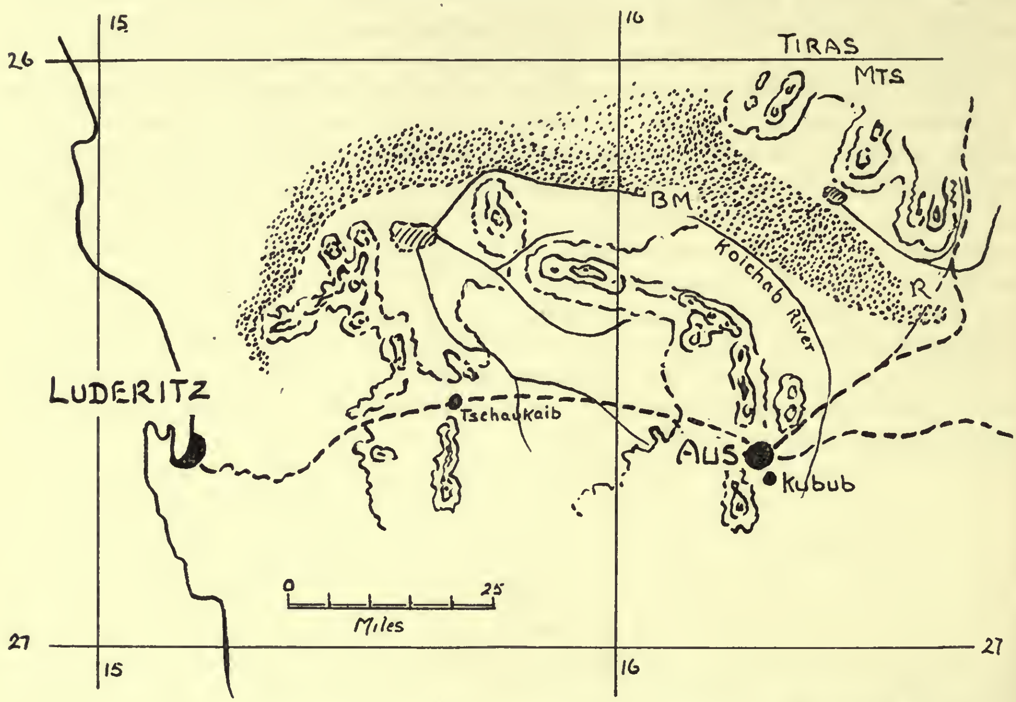

FIG. 1. Details of Aus area showing southern limit of shifting sand-dunes and localities in which Red-back larks were collected.

B.M. = B.M. Expedition collecting locality.
R. = Roberts's collecting locality.

hausen road, 30 miles north of Aus, touches an encroaching arm of the dunes. In fact it was evident that the road we used in 1950 is a new trace circumventing the dunes and that Roberts was almost certainly on the old road.

We explored the dunes about 30 miles farther west than Roberts did. They lay across our path in the form of a pinkish-red barrier of fine wind-blown sand rising several hundred feet. On the margins of the dunes there were numerous scattered clumps of a spiky grass, *Aristida* sp. Red-back larks were found living in association with this grass. (Conditions were similar to those at Tsondab Mund shown on Plate 38*b*.)

South of the dunes the country consists of a jumble of granite hills and kopjies rising from plains of firmer sand and gravel covered with low scrub, varying in density according to local conditions. Red-back larks may be found almost any-

where in this scrub. Niethammer records that he found them in small parties on the western edge of the Kubub plain where there were patches of small bushes. We came across them in several places north, south, and west of Aus.

There is no doubt that Aus (scrub) birds are different. They are clearly intermediate between the Aus (dune) and the Witputs birds, which also inhabit a similar sort of scrub, but smaller and sparser, frequently with a high proportion of succulents, and growing on a redder type of sand. Twelve specimens collected by us near Aus in late January and early February are adults just completing moult and are in perfectly fresh plumage. They are much paler than the Witputs birds, about OOS/9/5 as against OOS/6/6. Dark centres to body feathers on the upper parts are never blackish as they sometimes are in Witputs specimens, but are a darker tone of the same general colour. Dark streaks on the central tail feathers are on the whole appreciably reduced, and on the innermost secondaries are little more than the thickness of the shaft. Below, the streaking on the breast is much less distinct (see Plate 37). In Roberts's specimens, collected in July, the plumage is fairly worn, but the only change is in the loss of most of the pinkish 'bloom' which appears to be characteristic of all fresh adult plumages. There are no juveniles. Dimensions of British Museum and Transvaal Museum specimens are:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	14	91–100	67–76	19–21	27–38
♀	6	86–92	63–71	18–19	29–32

Namib Dunes

North of Aus

The Aus (scrub) birds are more like the sand-dune specimens from 30–40 miles north of Aus than the Witputs birds. Of six specimens collected on the dunes on the 31st of January, four are in the final stages of moult, while two are in half moult and still showing the appearance of the old worn plumage. The colour of the upper part in the fresh and worn plumage is indistinguishable from that of the Aus (scrub) birds, being about OOS/9/5 when fresh and about OOS/10/5 when faded. The main difference lies in the extreme narrowness of the dark centres of the central tail feathers which are reduced more or less to the width of the shaft. On the innermost secondaries it has disappeared altogether, even the shaft being the same colour as the web. Differences on the under parts are more noticeable: the streaking on the breast is reduced very considerably, both in the number of feathers with dark centres and the width of the dark centre, which is not blackish, as in the population samples already examined, but about the same colour as the upper parts (see Plate 37). Also the white of the under parts is washed with pale buff. In adults there is a greater amount of pinkish on the underside of the wing (on the inner margin of the inner web). It may be noted that this and other characters, such as the narrower width of dark centres on central tail feathers and inner secondaries, are associated with juvenile plumage in the Aus (scrub) and Witputs areas.

In the preserved specimens the bills of the dune birds have dried off to a dark

brownish-horn colour, whereas in the scrub birds they are blackish-horn. This difference is not reflected in the data noted in the field, but direct comparison of fresh specimens was not made and unless some standard colour nomenclature is used, field descriptions, even of the same colour, often vary from day to day.

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	8	91–97	68–71	18–20	28–32
♀	9	83–90	60–70	16–20	23–29

Tsondab Mund

A series of specimens was obtained at Tsondab Mund, about 180 miles north of Aus and 20 miles south of the Kuiseb River. The Tsondab is a seasonal river which has its origin in the Naukluft Mountains, and disappears in the sands of the Namib Desert, about 50 miles from the coast. It lies in a gravel plain flanked by mountainous dunes which eventually form a barrier across its course (see Plate 38*b*). The dunes are very similar to those at Aus. A series of eighteen specimens was obtained on the 5th and 6th of March, of which one is in juvenile plumage. The adults are either in extremely worn breeding dress, with gonads large but apparently subsiding, or just beginning to moult. They are, therefore, about two months later in their breeding-cycle than the population near Aus. A few are fairly well advanced in moult, sufficient to show that the colour of the fresh plumage is exactly similar to the Aus (dune) birds, being about OOS/9/5 when fresh and fading to about OOS/10/5, On the underside also colours and markings are identical, but in the worn condition the breast stripe almost disappears (see Plate 37). The juvenile is similar to the worn adult in colour, but is distinguishable by pale tips to most of the feathers, giving it a speckled appearance. Dimensions are:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	11	88–98	62–70	19–21	25–33
♀	6	83–88	60–66	18	25–31
Juv. ♀	1	82	60	16	29

Walvis Bay

The Kuiseb River forms the northern boundary of the main Namib sand-dune area. It is not certain exactly where C. J. Andersson obtained the specimens on which Strickland based his descriptions of *Alauda erythrochlamys*. Of those in the British Museum two carry the information 'sandy flood bed of the Kuiseb River'. He was stationed both at Walvis Bay and Sweppmansdorp (now Rooibank), about 30 miles up the Kuiseb. Roberts obtained specimens in 1941 at Rooibank 'at the edge of the sand dunes'. We spent a few days higher up, at Swartbank, but were on the north side and separated from the dunes by the Kuiseb in flood.

Of six specimens in the British Museum, two adults are dated November. They are in very worn plumage and compare exactly with worn and faded specimens from Tsondab Mund, about OOS/10/5. Of two in juvenile plumage one is dated May, and judging by the extent of wearing compared with a March specimen from Tsondab

Mund, must have been hatched out about the same month. It seems, therefore, that the breeding-cycles along the Kuiseb and Tsondab coincide. Dimensions are:

Sex	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
♂	4	90–93	67–68	19–21	26–28
♀	1	89	62	17	30
Juv. ♂	1	87	'86	18	—
?	3	89–90	67–68	17–19	28–29

Roberts and Meinertzhagen quote Swakopmund in the distribution of this lark. So far as I know specimens have not been found in that locality. Although there are dunes near the coast at Swakopmund we found them entirely lacking both in *Aristida* grass and Red-back larks. Roberts also mentions that Andersson took eggs of this species at Otjimbinque, and these are in the British Museum. As the eggs are not accompanied by the birds they belonged to their proper identification will remain uncertain until they can be compared with eggs known with certainty to belong to *A. erythrochlamys*.

DISCUSSION

Dimensions

The localities mentioned above are indicated on the accompanying map (Plate 36). The sample of specimens from each locality is, in the majority of instances, too small in relation to the number of factors affecting dimensions, such as, for example, the amount of wear, to obtain accurate statistical figures, but the measurements taken are approximate enough to give a general picture of correlation between the various populations. The only factor which need be taken into account is sex, but even here a high degree of accuracy in sexing cannot be claimed. Juvenile measurements do not appear to vary noticeably from those of adults. In any case, if they were to be dealt with separately, account would have to be taken of the first adult compound plumage in which juvenile wing and tail feathers are retained, but this stage does not appear to be recognizable. Measurements of males and females, including the juveniles of each sex, from the various localities, are compared in Tables 1 and 2,

TABLE 1. *Summary of the Dimensions of Males of All the Populations of Karroo and Red-back Larks*

Locality	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
Cape Flats	5	88–94	62–68	18–20	28–32
Berg River	3	91	62–68	19–20	31–32
Lambert's Bay	1	92	71	19	—
Swellendam	2	92–94	66–69	15	28–29
Namaqua–Bushman-land Region	40	86–100	62–74	17–20	28–36
Orange River	8	86–96	63–68	20–21	26–30
Witputs	8	89–96	65–72	20–21	26–32
Aus (scrub)	14	91–100	67–76	19–21	27–38
Namib: Aus (dunes)	8	91–97	68–71	18–20	28–32
Tsondab Mund	11	88–98	62–70	19–21	25–33
Walvis Bay	5	87–93	67–68	12–21	26–28
Total	105	86–100	62–76	17–21	25–36

TABLE 2. *Summary of the Dimensions of Females of All the Populations of Karroo and Red-back Larks*

Locality	*No.*	*Wing*	*Tail*	*Bill*	*F.P.*
Cape Flats	4	82–88	56–61	18–20	27–33
Berg River	1	88	61	20	27
Swellendam	1	84	62	16	26
Namaqua–Bushman-land Region	22	84–93	58–67	16–20	26–32
Orange River	4	82–87	61–64	17–19	26–27
Witputs	10	78–87	59–65	17–18	26–30
Aus (scrub)	6	86–92	63–71	18–19	29–32
Namib: Aus (dunes)	9	83–90	60–70	16–20	23–29
Tsondab Mund	7	82–88	60–66	16–18	25–31
Walvis Bay	1	89	62	17	30
Total	65	78–93	56–71	16–20	23–33

which summarize the full data given in the 'Tables of Measurements' at the end. From this it is seen that none of the samples, or group of samples, under examination is readily separated from the others.

The uniformity apparent in this general picture can be tested by examination of the frequencies of the dimensions taken. It seems legitimate to emphasize any small differences by combining lengths of wing, tail, and bill (first primary measurements being omitted only because they are less complete). This has been done separately for males and females and the result is shown logarithmically in Fig. 2. Males have a mean value of 180 mm. and females 167·5, with standard deviations of 6 and 5 respectively. The main point, however, is that the distributions are approximately symmetrical, suggesting that the sample belongs to a more or less uniform population.

In fact the sample is so uniform that a cline is not even evident. When Namib dune populations are tested against populations from the Namaqua–Bushman-land area an almost exact correlation is obtained. For instance, in Fig. 3 the size-frequencies of the wing lengths of the males of these two populations are shown as histograms and are plotted logarithmically. The difference of the means (0·1 mm.) is so low that it is clearly of no significance; about 95 per cent. of random samples of a single population would show a mean difference of this magnitude, or greater.

At this point it may be noted that Roberts (1937: 97) distinguished his *Calendulauda guttata calviniensis* only on size; he gives wing measurements as ♂ 99, ♀ 90 (by my measurements 98 and 89), both of which lie within the range given here. Apparently he only had two specimens and a larger sample from the same locality obtained by Meinertzhagen shows a wider range: 5 males, wing 90–96, 2 females, wing 85–89. In this short series the mean wing length of the males, 93·9 mm., differs from the mean length of the Namaqua–Bushman-land populations by only 1 mm., and the type male alone differs from the mean by an amount greater than the standard deviation of the populations.

Colour and pattern

In general appearance birds are coloured above in various tones of reddish-orange which is either plain or marked with very dark streaks: the under parts are whitish,

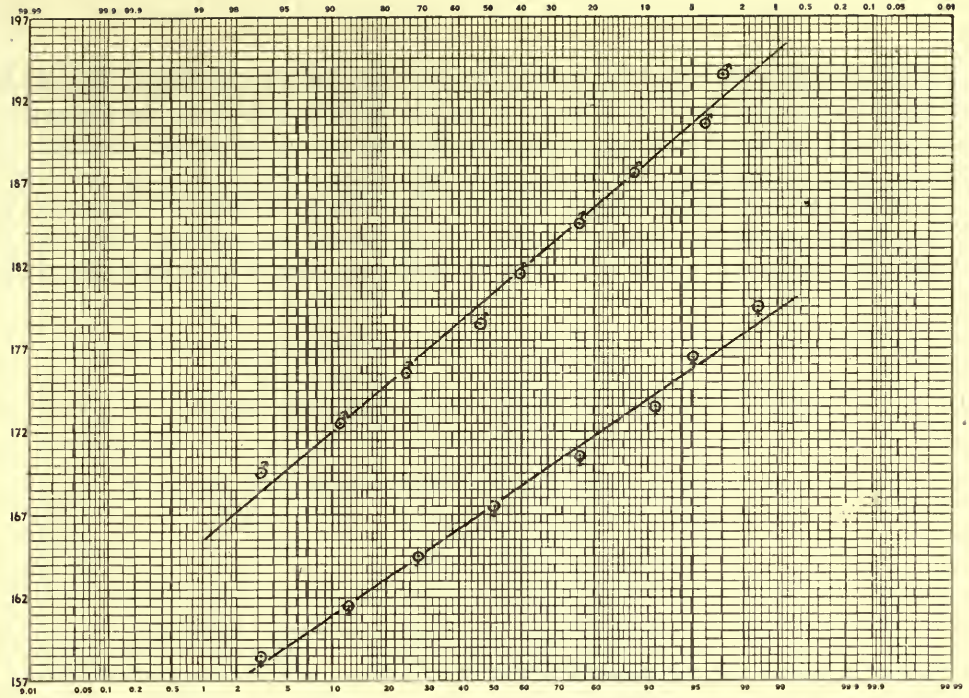

FIG. 2. Size-frequencies of combined wing, tail, and bill lengths of 97 males and 64 females from all the populations of Karroo and Red-back larks.

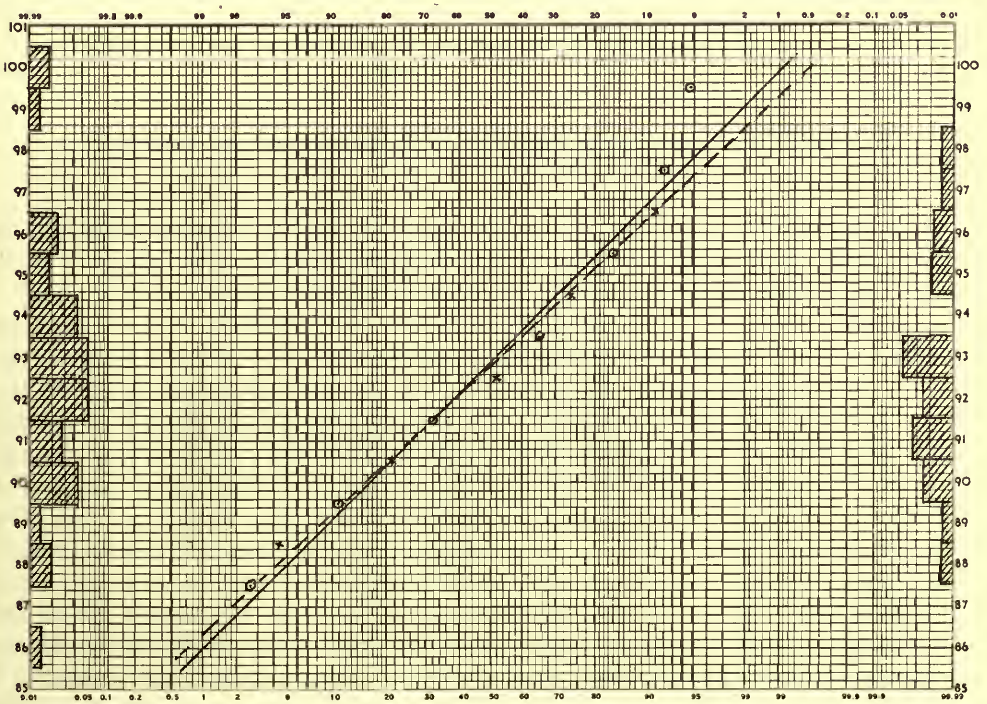

FIG. 3. Size-frequencies of wing lengths in males of: (*a*) Namaqua–Bushman-land populations, 37 specimens; circles and unbroken line. Mean 92·9 mm.; σ, 3·0. (*b*) Namib dune populations, 23 specimens; crosses and broken line. Mean 92·8 mm.; σ, 2·7.

with dark streaks at least on the breast. In all body-feathers, both above and below, the basal portion (at least two-thirds or more) is uniformly very dark grey. The usual pattern of the exposed tip consists of a dark central streak, flanked by a coloured area of medium tone, and a thin pale outer margin (see Fig. 4). On the whole these parts are fairly sharply defined. The pale outer margin is most evident in the juvenile plumage, where it forms a fairly broad whitish tip. Pale margins are also present sometimes in new adult feathers, but they are usually very narrow

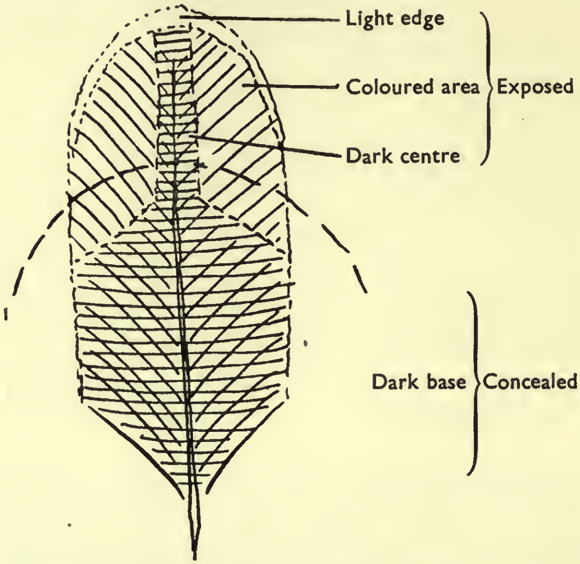

Fig. 4. Diagrammatic representation of the colour pattern of a feather taken from the centre of the back.

and soon wear off. In some localities, particularly the Springbok area, broad whitish margins to the feathers of the wing coverts contrast sharply with blackish centres and form a pattern which persists throughout the season.

The general colour of the upper parts is mainly determined by the coloured area of medium tone. It is this colour which has been identified and used for comparative purposes. In all the specimens examined the colours of this area belong to the same hue, as identified by the *Colour Atlas*. They vary only in the degrees of lightness and chromaticity. An attempt has been made to show the extent of this variation in Fig. 5. Two general points of special interest which are illustrated are that the less colourful and rather paler forms are distributed along the coast from Cape Town to the mouth of the Orange River; otherwise birds of the main population have the same chromatic value, varying only in degree of lightness.

As well as variation in tone the coloured area varies in the amount of the exposed tip it occupies. In the northern Namib birds it occupies the whole of the exposed tip, the dark centres being non-existent except in a few of the breast feathers. In Aus birds the dark centres are slightly more pronounced, and become more so at

Witputs and the Orange River. In the Springbok region there is a sudden increase in the ratio of dark centres to coloured area, so much so that in this particular feature birds at Orange River mouth are more unlike birds from Port Nolloth, only 60 miles

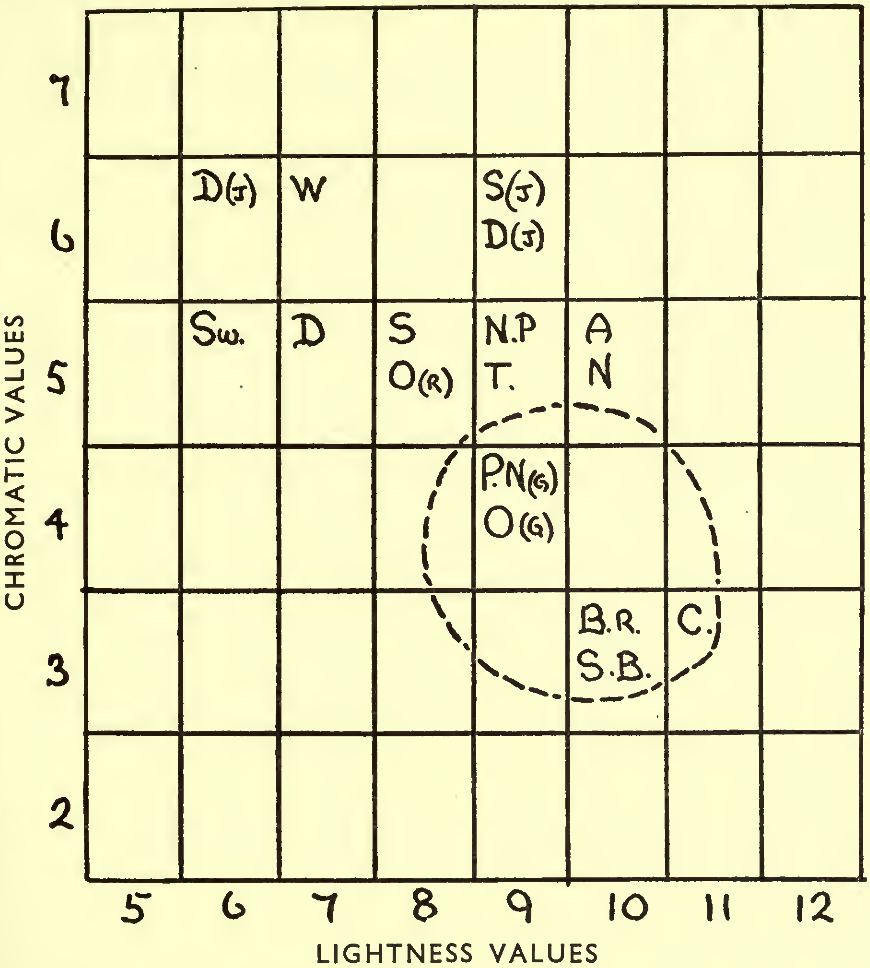

Fig. 5. Graphical representation of colour variation based on Villalobos's *Colour Atlas*. The area ringed indicates the grey coastal population.

A = Aus; B.R. = Berg River; C = Cape; D = Deelfontein; N = Namib; N.P. = Nels Poort; O = Orange River; S = Springbok; SW = Swellendam; S.B. = Saldanha Bay; T = Traka; W = Witputs; (G) = Grey phase; (R) = Red phase; (J) = Juvenile.

away, than birds from the Namib dunes. Birds from Springbok southwards could be described as being heavily streaked, with a tendency in some places in the south for the dark centres to occupy nearly the whole area of exposed feathers. Birds north of Springbok are lightly streaked, with a tendency in the north for the coloured area to occupy nearly the whole of the exposed part of the feather. There is therefore a more or less graded change in pattern correlated with north and south

distribution. There does not seem to be any correlation between colour and pattern. The populations which have similar broad streaks are variable in colour.

Developmental stages

The juvenile plumage is distinct from the adult plumage. Most of the feathers have a fairly broad whitish margin at the tip, the dark central streaks are narrower, and in general appearance the plumage lacks the particular pinkish bloom which seems to be typical of all adult fresh plumages. On the whole the colour of juvenile plumages most closely resembles worn and faded adult plumages, but it may be noted that of two young birds obtained in the Deelfontein area, by the same collector in 1901, a very young March specimen is more richly coloured than adults, while a rather worn January specimen is rather lighter and browner and agreeing with the more usual relationship between juvenile and adult. The significance of this difference does not seem to be apparent at this stage. Moult from juvenile to first adult plumage seems to take place slightly later than the adult post-breeding moult. Only the body-feathers are moulted and therefore the first adult plumage is compound. It may be noted that it is possible that this stage may be rather less deeply coloured in populations of deeply coloured adults. Moult proceeds in an anterior-posterior sequence.

In the adult plumage there is an appreciable seasonal change due to wear and fading, new feathers having a noticeable pinkish bloom. In the material studied there is no indication of pre-nuptial moult, partial or otherwise, so that the moult cycle seems to be Juvenile → Compound Annual → Simple Annual (repeating). In the adult post-breeding moult there is a complete change of feathers. Body moult proceeds in the same sequence as in the juvenile and is usually rather ahead of wing and tail, in which the sequence follows the normal pattern, beginning at the junction of primaries and secondaries in the wing and the central pair of feathers in the tail.

The pattern of development therefore is uniform throughout the group, and in the rather limited material examined there seems to be rather less variation in the juvenile than in the adult, the former being constantly browner in colour because of the narrower dark feather streaks.

Breeding-cycle

In the northern sector of the range there are indications of a progressively later breeding-cycle correlated with decrease in latitude. Birds at Kamieskroon (30° south) had commenced post-nuptial moult in late November, whereas at Tsondab Mund (24° south) it was early March before birds reached the same stage. In the southern sector, however, the correlation is confused, as might be expected when the distribution spreads eastwards. The factors determining the breeding-cycle have not been investigated. A similar gradation in breeding-cycle was found in the Long-bill lark, *Certhilauda curvirostris* (see Macdonald, 1952).

Habits

Regarding the habits of these birds, Smith (1843) stated of his *A. codea* that 'when

disturbed they fly to a distance, and then perch upon the summit of some dwarf shrub'; and of his *A. lagepa* 'on descending from its aerial flight commonly perches on the shrub nearest to the point where it descends'. Notes by Andersson (1872), according to Gurney, are not related with certainty to any birds belonging to this group. Layard (1867: 209) under *A. codea* records some observations on the habits of nesting birds. Grant, in Sclater (1911: 256), records (under *Mirafra nivosa*—an invalid name, see footnote p. 321) that 'it frequents open flats and the tops of mountain ranges, and is usually in pairs. The call is a whistle, and the bird is fond of perching on the tops of low bushes and scrub, especially if disturbed'. Jack Vincent found his birds at Blaauwberg beach 'among low scrub on sand dunes'. An account of the nesting and other habits of the Cape race is given by A. W. Vincent (1946: 466). Roberts makes a few references to habits. Hoesch & Niethammer (1940: 224) recorded of the Red-back lark that they found it in small parties on the western edge of the Kubub (Aus) plain where there were patches of small bushes, and also that they run very fast over the sand and stop motionless in the cover of bushes.

Of birds in the Springbok area we noted that they were usually found in places where scrub became sparse and stunted and the soil loose and sandy or gravelly. On the ground they ran vigorously. They were never seen to make more than short low flights which were rather weak and fluttering. In our experience they always landed on the ground, making what appeared to be a 'pancake' landing, but they would jump on to low scrub. Local populations seemed to be thinly scattered in ones and twos. At Grootderm, near the mouth of the Orange River, they were found in rather more arid conditions, in depressions between low hills on soft sand with scattered stones and rocky outcrops, and practically no scrub, but what scrub there was the birds used for cover, running from one tuft to another. On the few occasions on which observations were made none were seen to perch. At Witputs they were again associated with open scrub, about 18 inches high, and soft sand. They were relatively plentiful, usually in scattered pairs, but took a good deal of finding until one became acquainted with the places they liked and their habit of creeping about, mouselike, of standing motionless under a clump of scrub, or of running at great speed with head down, but then frequently giving themselves away by jumping up on top of the scrub. They were difficult to flush, and flew low for very short distances. At Aus the picture was much the same: birds were most frequently found on sandy patches with sparse stunted scrub, and when disturbed ran for long distances. Sand-dune birds from north of Aus and Tsondab Mund were not noticeably different. They lived in close association with *Aristida* grass, sheltering in the clumps, or running with amazing speed from one clump to another, easily outpacing our clumsy efforts to catch up with them. Probably because of this we noted that they seemed to be wilder than other Red-backs, but then they were living in a more exposed environment. They sometimes jumped up on top of the grass tufts, but were never seen to alight there from flight. A display flight was noted, in some ways reminiscent of the skylarks. Birds climbed up to 100 feet or so then fluttered horizontally for a short distance uttering a rather musical note which was written down as 'chek-chek-chek-chek-tae': they would drop 10 or 20 feet, flutter again for a short distance, then drop suddenly to earth, and run. A variation of this note was

sometimes uttered by a bird standing in or on a clump of grass: it was recorded as 'tchee-tchee-tchee-chr-r-r-r'.

It seems clear, therefore, that the birds known as Karroo and Red-back larks live in similar habitats, namely, areas of soft sand where vegetation is sparse, and that there seems to be a good deal of similarity in their habits.

Nomenclature

It would be convenient to summarize the foregoing and leave the matter there, for it is obvious that much more data has to be obtained before an accurate picture of the taxonomy of this group can be presented. But for cataloguing purposes the question of nomenclature has to be dealt with.

The general picture is of a group of populations which are practically identical dimensionally, but variable in several other characteristics, particularly colour-tone and feather pattern. These variations appear to be independent of each other, but, for the most part, they can be correlated with distribution. Streaking is heaviest in the southern birds and almost completely disappears in the northern. Colour bears a broad general relationship to soil colour. In fact, putting both together, plumage colour and pattern bears some relation to soil colour and pattern. In the smooth fine sands of the Namib dunes birds are plain; whereas in the Springbok area, for example, where there is much more gravel and stones and prostrate vegetation breaking up the surface of the sandy localities frequented by these birds, they are patterned. A striking colour variation is associated with a narrow coastal belt which has greyish sands and frequent coastal fogs.

It seems highly probable that these variable characteristics are largely phenotypic in origin and of less significance taxonomically than those which are less variable, such as dimensions; and therefore, taking into consideration the allopatric nature of the distribution, it can be concluded that all these various populations are representatives of a single species.

This lark seems to be related to the Long-bill lark, *Certhilauda curvirostris*, which occupies rather stonier types of country within practically the same area of distribution, and is the type species of the genus *Certhilauda*. The specific name of the Karroo and Red-back larks therefore is *Certhilauda albescens* (Lafresnaye).

The question as to which populations should carry distinctive names is more difficult to answer. Grey birds appear to be restricted to coastal localities between the Cape and the Orange River. Cape area populations seem to be entirely grey and of a distinctive tone and therefore may be given racial status. But from Lambert's Bay north to Port Nolloth populations are mixed grey and red, though predominantly the former. This mixing seems to have been the main reason for Roberts's recognition of two species and Meinertzhagen's reversion to a single polymorphic Karroo Lark not divisible into races. My own opinion is that the coastal strip in which grey birds predominate is no wider than the zone of overlap or infiltration which one would expect to find between two geographical forms whose differences are not apparently intergraded (see map, Plate 36). Some overlap may be due to birds wandering in the non-breeding season and the balance of grey over red being maintained no doubt by those factors which are the primary cause of a grey phase being

established in this area. I think, therefore, that it presents a better picture of the taxonomy of the species to give them racial status and, until more is known about them, to tack them on to the Saldanha Bay form.

The inland red populations are, in my opinion, not well enough known as yet, throughout their wide distribution, to be regarded as anything other than a single race, *guttata*. In the north the scrub and dune populations are distinct and have been named, but in the Witputs area, and near the mouth of the Orange River, there are distinct populations for which names have to be provided. Regarding the latter, the type is one of a series of grey birds, and it may well be that when more becomes known about populations in this area that an inland red form will be distinguished.

The nomenclatorial picture, therefore, is as follows:

Certhilauda albescens (Lafresnaye)

(1) *C. a. albescens* (Lafr.)

Alauda albescens Lafresnaye, *Rev. Zool.* 1839: 259: Blaauwberg Beach, Table Bay.

Alauda codea Smith, *Zool. of S. Africa*, 1843, pl. 87: Karroo plains, between the Oliphant's and Orange Rivers. (Probably Cape Flats.)

Characteristics. General appearance of upper parts light drab, broadly streaked with sepia. Below whitish broadly streaked with sepia on breast, lightly streaked on flanks and almost entirely without streaks on belly.

Distribution. Cape Flats, as far north as Berg River.

(2) *C. a. saldanhae* (Roberts)

Calendulauda albescens saldanhae Roberts, *Ann. Trans. Mus.* 1936: 258: Saldanha Bay, Cape Province.

Characteristics. Similar to previous race, but with a pinkish-rufous wash on the upper parts. The extent to which this feature is constant in the areas indicated is not certain.

Distribution. Saldanha Bay, Berg River, Lambert's Bay, and northwards along the coast to Port Nolloth.

(3) *C. a. guttata* (Lafr.)

Alauda guttata Lafresnaye, *Rev. Zool.* 1839: 259: Elephant's (Oliphant's) River, Cape Province.

Alauda legepa Smith, *Zool. of S. Africa*, 1843, pl. 87: between the Berg and Orange Rivers.

Calendulauda albescens karruensis Roberts, *Ann. Trans. Mus.* 1936: 258: de Aar, Cape Province.

Calendulauda guttata calviniensis Roberts, *Ostrich*, 1937 (97): Calvinia, Cape Province.

Characteristics. Similar to previous races in the extent of sepia streaking above and below, but general colour of upper parts about snuff-brown to Mikado-brown.

Some variation in colour is evident, but so far not clearly associated with distribution.

Distribution. Inland areas from Swellendam in the south, north-east to de Aar and west to Springbok, and apparently sometimes reaching the coast, as at Port Nolloth and Lambert's Bay.

(4) *C. a. patae* new race

Characteristics. Upper parts very lightly streaked and dark central streak on inner secondaries and central tail feathers much reduced. Below, streaks confined entirely to breast. Two colour phases known from the type locality, one similar to the general colour of *C. a. guttata* and the other to the general colour of *C. a. saldanhae.*

Distribution. South bank of the Orange River near its mouth to coast about 10 miles south.

Type. One of the 'grey' phase. Male; collected at Grootderm, Orange River, Little Namaqualand, lat. 28° 31′ S., long. 16° 38′ E., alt. 500 ft., on 17th December 1949 by the British Museum South West Africa Expedition (1949–1950). Register number 1950:50:936. Wing 89, tail 67, bill 21. Iris brown, legs pale yellow-grey, bill black. Approaching final stages of moult.

Remarks. The series consists of seven 'grey' phase and two 'red' phase, obtained in mid-December: three 'grey' specimens in the Transvaal Museum were obtained at Orange Mouth in September.

(5) *C. a. cavei* new race

Characteristics. On the whole rather less streaked above than the Orange River birds, and upper parts darker and richer in colour than 'red' specimens from that area, about cinnamon-brown. Streaking below much the same.

Distribution. At the southern end of the Huib Plateau in the vicinity of Witputs, Great Namaqualand.

Type. Male; collected 5 miles south-west of Witputs, Great Namaqualand; lat. 27° 35′ S., long. 16° 42′ E., alt. 4,000 ft.; on 26th January 1950, by the British Museum South West Africa Expedition (1949–1950). Register number 1950:50:922. Length of wing 96, tail 71, bill 21. Iris dull brown, legs pale grey, bill dark grey.

Remarks. Eighteen specimens, three of which are juvenile, were obtained in late January.

(6) *C. a. barlowi* (Roberts)

Pseudammomanes barlowi Roberts, *Ostrich,* 1937: 95: 8 miles west of Aus, Great Namaqualand.

Characteristics. Plain above, with no indication of dark central streaks on body feathers: streaks on inner secondaries and central tail feathers reduced to little more than a thin line. General tone of colour much lighter than Witputs birds,

about sayal-brown. Below, dark streaks on breast distinctly lighter, narrower, and occupying a smaller area: white ground colour washed with pale buff. Bill, blackish-horn.

Distribution. Vicinity of Aus, Great Namaqualand: extending at least 20 miles west, 6 miles north, and about 3 miles south.

(7) *C. a. erythrochlamys* (Strickland)

Alauda erythrochlamys Strickland, *Contr. Orn.* 1852: 181: Damaraland (probably Kuiseb River near Walvis Bay).

Characteristics. Plain above and similar in colour-tone to previous race, but lacking dark centres to inner secondaries and central tail feathers. Below, streaking on breast much reduced, and dark cinnamon-brown rather than sepia; white ground colour more washed with buffish; and more pinkish-buff on underside of wing. (It may be noted that several of these features are found in the juvenile stages of *C. a. barlowi* and *C. a. cavei.*) Bill, brownish-horn.

Distribution. Namib sand-dune area from the Koichab River basin just north of the Aus, north to the Kuiseb River as far as Walvis Bay, and inland as far as the dunes extend and apparently where spiky *Aristida* grass occurs.

SUMMARY

1. Samples of various populations of Karroo and Red-back larks have been examined, particularly as regards dimensions, colour, pattern, moult, breeding-cycle, development, habits, and habitat.

2. The differences found are no greater than might be expected in random samples of the same species, and it is concluded that Karroo and Red-back larks can be regarded as one species, *Certhilauda albescens* (Lafresnaye).

3. Variation in colour and pattern are broadly correlated with the colour of the soil and the pattern of the environment; plainness being associated with an environment of smooth sand and streakiness with a broken pattern.

4. Although colour and pattern vary independently, seven geographical races based on these characteristics can be recognized. Two are newly described.

5. It is noted that data is still very inadequate and much still remains to be found out, particularly as regards distribution and variation in populations in Cape Province, and that the racial picture presented for birds in that area may be subject to amendment.

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TABLES OF MEASUREMENTS

Abbreviations: B.M.—British Museum
T.M.—Transvaal Museum
S.A.M.—South African Museum
M.C.—Meinertzhagen Collection
F.P.—First Primary
V.C.—B.M. Vellum Catalogue

C. a. albescens

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Cape of Good Hope*	?	?	Ad.	?	90	64	17	33	B.M.
,,	?	?	Ad.	?	88	63	19	31	B.M. 45:7:6:212
,,	?	?	Ad.	?	89	63	19	27	B.M. V.C. 18:19*a*.
Cape Town	?	S.L.	Ad.	?	85	60	18	28	B.M. 70:12:31:750
Blaauwberg	21:6	S.L.	Ad.	♂	91	64	19	?	B.M. 1937:7:14:238
,,	21:6	S.L.	Ad.	♀	88	62	19	33	B.M. 1937:7:14:237
Milnerton	?	S.L.	Ad.	♂	88	64	18	32	S.A.M. 13272
,,	?	S.L.	Ad.	♂	93	67	20	32	T.M. 20765
,,	?	S.L.	Ad.	♀	83	56	?	30	S.A.M. 13273
,,	?	S.L.	Ad.	♀	82	57	18	28	S.A.M. 13273
,,	?	S.L.	Ad.	♀	84	60	19	29	S.A.M. 13273
Durban Road	11:4	?	Ad.	♂	90	62	19	28	S.A.M. 14910
Philadelphia	10:4	?	Ad.	♂	94	68	20	30	S.A.M.
Berg River	?	?	Ad.	♀	88	61	20	27	B.M. 76:5:23:705
8 mls. NE. of Cape Town	26:4	?	Ad.	?	87	60	19	32	M.C.

* Type of *Alauda codea* Smith.

C. a. saldanhae

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Saldanha Bay*	15:11	S.L.	Ad.	♂	91	62	19	?	T.M. 11881
,,	10:10	S.L.	Ad.	♂	91	66	20	32	S.A.M. 7708
,,	10:10	S.L.	Ad.	♂	91	68	19	31	S.A.M. 7809
Berg River	?	?	Ad.	?	90	64	20	29	B.M. 76:5:23:706
,,	?	?	Ad.	?	93	66	20	30	B.M. 89:9:13:82
Lambert's Bay	29:10	?	Ad.	♂	92	71	19	?	T.M. 11878
Port Nolloth	19:8	S.L.	Ad.	♂	95	71	20	32	B.M. 1950:52:12
,,	19:8	S.L.	Ad.	♂	95	72	22	?	T.M. 20901
,,	19:8	S.L.	Ad.	♀	87	66	18	?	T.M. 20899
,,	20:8	S.L.	Ad.	♀	85	64	19	?	T.M. 20902
25 mls. E. of P. Nolloth	20:8	500	Ad.	♀	86	61	20	?	T.M. 20903

C. a. guttata

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Swellendam	?	?	Ad.	?	83	62	18	30	B.M. 74:4:5:656
Nels Poort	?	?	Ad	?	92	64	17	26	B.M. 79:4:5:657
Traka	?	?	Ad.	?	91	68	?	34	B.M. 79:4:5:658
Deelfontein	23:2	?	Ad.	♂	94	69	?	28	B.M. 1903:3:9:470
,,	28:2	?	Ad.	♀	84	62	16	26	B.M. 1903:3:9:471
,,	28:1	?	Juv.	♂	92	66	15	29	B.M. 1901:9:5:23
,,	7:3	?	Juv.	♀	?	?	?	?	B.M. 1901:9:5:26
Berg-Orange River†	?	?	Ad.	?	90	65	19	28	B.M. 1845:7:6:213
Klaver	28:9	?	Ad.	♂	92	66	18	?	T.M. 11874
,,	28:9	?	Ad.	♂	93	67	18	33	S.A.M.
van Rhynsdorp	?	?	Ad.	♂	93	65	19	30	T.M. 15211
,,	?	?	Ad.	♀	85	60	18	?	T.M. 15210
,,	?	?	Ad.	♀	84	60	18	29	T.M. 15209
Calvinia‡	?:8	?	Ad.	♂	99	72	19	?	T.M. 29012
,,	?:8	?	Ad.	♀	89	64	17	?	T.M. 20913
,,	30:4	?	Ad.	♂	93	71	18	35	M.C.
,,	30:4	?	Ad.	♂	95	72	18	33	M.C.
,,	30:4	?	Ad.	♂	90	67	18	33	M.C.
,,	1:5	?	Ad.	♂	96	69	?	32	M.C.
,,	1:5	?	Ad.	♂	90	66	18	32	M.C.
,,	1:5	?	Ad.	♀	85	66	18	28	M.C.
,,	30:4	?	Ad.	♀	89	65	17	26	M.C.
40 mls. E. of C.	2:5	?	Ad.	♂	90	64	18	29	M.C.
,,	2:5	?	Ad.	♂	92	66	19	29	M.C.
,,	2:5	?	Ad.	♂	94	71	18	31	M.C.
,,	2:5	?	Ad.	♀	89	66	17	30	M.C.
Brandvlei	3:5	?	Ad.	♂	94	71	18	31	M.C.
Nr. Carnarvon	12:6	?	Ad.	♂	90	71	17	27	M.C.
Kamieskroon	25:9	2,500	Ad.	♂	94	68	?	32	S.A.M. 18231
,,	28:9	2,500	Ad.	♂	96	71	?	32	S.A.M. 18233
,,	30:9	2,500	Ad.	♂	92	65	19	36	S.A.M. 18232
,,	2:12	2,500	Ad.	♂	88	63	17	32	B.M. 1950:50:940
,,	2:12	2,500	Ad.	♂	93	68	18	33	B.M. 1950:50:939
,,	4:12	2,500	Ad.	♂	91	65	19	28	B.M. 1950:50:934
,,	3:12	2,500	Ad.	♀	86	60	17	27	B.M. 1950:50:942
,,	3:12	2,500	Juv.	♀	86	64	18	32	B.M. 1950:50:941
Grootberg	29:7	?	Ad.	♂	93	67	18	36	B.M. 73:10:20:145
,,	29:7	?	Ad.	♀	84	61	?	27	B.M. 73:10:20:232
Springbok	6:12	2,600	Ad.	♂	94	68	18	34	B.M. 1950:50:945
,,	7:12	2,600	Ad.	♂	100	71	19	31	B.M. 1950:50:946
,,	7:12	2,600	Juv.	♂	89	70	17	32	B.M. 1950:50:948
,,	7:12	2,600	Juv.	♂	91	74	17	28	B.M. 1950:50:947
,,	6:12	2,600	Ad.	♀	89	65	19	30	B.M. 1950:50:944
NW. of Springbok	8:5	?	Ad.	♂	86	70	19	?	M.C.
,,	8:5	?	Ad.	♂	94	70	19	33	M.C.
,,	8:5	?	Ad.	♂	100	74	20	31	M.C.

* Type of *Calendulauda albescens saldanhae* Roberts. † Co-type of *Alauda lagepa* Smith.

‡ Type of *Calendulauda guttata calviniensis* Roberts.

C. a. guttata (cont.)

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
NW. of Springbok	8:5	?	Ad.	♂	96	72	19	36	M.C.
,,	8:5	?	Ad.	♀	90	65	18	33	M.C.
,,	8:5	?	Ad.	♀	87	63	17	30	M.C.
Klipfontein	1:7	3,000	Ad.	♂	88	65	18	31	B.M. 1905:12:29:1437
,,	17:8	3,000	Ad.	♂	91	68	17	?	T.M. 20904
,,	22:12	3,000	Ad.	♂	92	?	18	29	B.M. 1950:50:952
,,	9:4	3,000	Ad.	♀	85	63	17	28	B.M. 1905:12:29:1436
,,	5:4	3,000	Ad.	♀	90	65	17	28	B.M. 1905:12:29:1435
,,	10:7	3,000	Ad.	♀	87	64	18	30	B.M. 1905:12:29:1438
,,	22:12	3,000	Ad.	♀	86	60	17	30	B.M. 1950:50:1000
Anemous	1:4	600	Ad.	♂	90	67	?	33	B.M. 1905:12:29:1440
,,	1:4	600	Ad.	♂	92	63	19	28	B.M. 1905:12:29:1439
25 mls. E of P. Nolloth	19:8	500	Ad.	♂	92	67	18	?	T.M. 20905
,,	19:8	500	Ad.	♂	93	66	19	?	T.M. 20907
,,	19:8	500	Ad.	♂	90	62	19	?	T.M. 20908
,,	19:8	500	Ad.	♂	95	66	19	?	T.M. 20909
,,	22:8	500	Ad.	♂	91	62	20	?	T.M. 20911
,,	21:8	500	Ad.	♀	85	61	19	?	T.M. 20910
,,	19:12	500	Ad.	♀	86	60	17	28	B.M. 1950:50:950
,,	19:12	500	Ad.	♀	83	59	17	29	B.M. 1950:50:951
,,	19:12	500	Ad.	♀	93	66	18	29	B.M. 1950:50:949
Port Nolloth	4:8	S.L.	Ad.	♂	89	63	19	30	B.M. 1905:12:29:1442
,,	21:7	S.L.	Ad.	♀	86	58	20	30	B.M. 1905:6:20:10
,,	18:7	S.L.	Ad.	♀	88	61	18	27	B.M. 1904:6:20:9

C. a. patae

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Grey Phase									
38 mls. N. of P. Nolloth	19:12	S.L.	Ad.	♂	86	63	20	?	B.M. 1950:50:938
Grootderm	11:12	500	Ad.	♂	89	?	20	27	B.M. 1950:50:937
,,	13:12	500	Ad.	♂	96	68	20	27	B.M. 1950:50:933
,,	17:12	500	Ad.	♂	92	64	21	26	B.M. 1950:50:934
,, *	17:12	500	Ad.	♂	89	67	21	?	B.M. 1950:50:936
,,	13:12	500	Ad.	♀	84	61	18	26	B.M. 1950:50:932
,,	17:12	500	Ad.	♀	86	62	17	27	B.M. 1950:50:935
Orange Mouth	24:9	S.L.	Ad.	♂	86	64	20	30	T.M. 25274
,,	?:9	S.L.	Ad.	♀	87	64	19	?	T.M. 25275
,,	?:9	S.L.	Ad.	♀	82	62	17	?	T.M. 25276
Red Phase									
Grootderm	13:12	500	Ad.	♂	86	63	21	30	B.M. 1950:50:929
,,	17:12	500	Ad.	♂	89	67	20	29	B.M. 1950:50:930

C. a. cavei

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Witputs	23:1	4,000	Ad.	♂	93	69	21	29	B.M. 1950:50:928
,,	24:1	4,000	Ad.	♂	92	69	20	?	B.M. 1950:50:926
,,	24:1	4,000	Ad.	♂	95	70	20	30	B.M. 1950:50:913
,,	24:1	4,000	Ad.	♂	96	70	20	33	B.M. 1950:50:924
,,	24:1	4,000	Ad.	♂	93	70	19	?	T.M. (C 205)
,, †	26:1	4,000	Ad.	♂	96	71	21		B.M. 1950:50:922
,,	25:1	4,000	Juv.	♂	89	65	20	26	B.M. 1950:50:916
,,	25:1	4,000	Juv.	♂	91	72	20	19	B.M. 1950:50:918
,,	23:1	4,000	Ad.	♀	85	64	18	?	B.M. 1950:50:925
,,	23:1	4,000	Ad.	♀	83	59	18	28	B.M. 1950:50:923
,,	25:1	4,000	Ad.	♀	87	64	18	26	B.M. 1950:50:912
,,	26:1	4,000	Ad.	♀	85	62	18	?	B.M. 1950:50:915
,,	26:1	4,000	Ad.	♀	84	64	17	?	B.M. 1950:50:920
,,	26:1	4,000	Ad.	♀	86	64	18	29	B.M. 1950:50:921
,,	27:1	4,000	Ad.	♀	85	63	18	27	B.M. 1950:50:927
,,	24:1	4,000	Juv.	♀	78	65	17	30	B.M. 1950:50:914
,,	25:1	4,000	Juv.	♀	84	64	17	27	B.M. 1950:50:919
,,	26:1	4,000	Juv.	♀	82	61	17	28	B.M. 1950:50:917

* Type of *C. a. patae*. † Type of *C. a. cavei*.

C. a. barlowi

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Aus (scrub)*	31:7	5,000	Ad.	♂	91	68	20	?	T.M. 20876
,,	31:7	5,000	Ad.	♂	95	67	20	30	B.M. 1950:52:10
,,	30:1	5,000	Ad.	♂	98	74	20	34	B.M. 1950:50:908
,,	2:1	5,000	Ad.	♂	96	76	20	?	B.M. 1950:50:907
,,	1:2	5,000	Ad.	♂	96	73	20	33	B.M. 1950:50:906
,,	1:2	5,000	Ad.	♂	98	74	20	38	B.M. 1950:50:910
,,	1:2	5,000	Ad.	♂	100	75	21	27	B.M. 1950:50:901
,,	1:2	5,000	Ad.	♂	97	74	20	?	B.M. 1950:50:902
,,	1:2	5,000	Ad.	♂	94	70	20	?	T.M. (M. 269)
,,	1:2	5,000	Ad.	♂	97	73	19	?	B.M. 1950:50:905
,,	2:2	5,000	Ad.	♂	93	70	19	29	B.M. 1950:50:911
,,	31:7	5,000	Ad.	♂	96	72	21	?	T.M. 20881
,,	31:7	5,000	Ad.	♂	95	71	19	?	T.M. 20879
,,	31:7	5,000	Ad.	♂	94	72	20	?	T.M. 20880
,,	30:1	5,000	Ad.	♀	90	66	19	29	B.M. 1950:50:909
,,	1:2	5,000	Ad.	♀	86	66	18	?	B.M. 1950:50:900
,,	1:2	5,000	Ad.	♀	89	68	18	32	B.M. 1950:50:904
,,	1:2	5,000	Ad.	♀	92	71	18	?	B.M. 1950:50:903
,,	31:7	5,000	Ad.	♀	88	63	18	?	T.M. 20878
,,	31:7	5,000	Ad.	♀	86	64	18	?	T.M. 20883

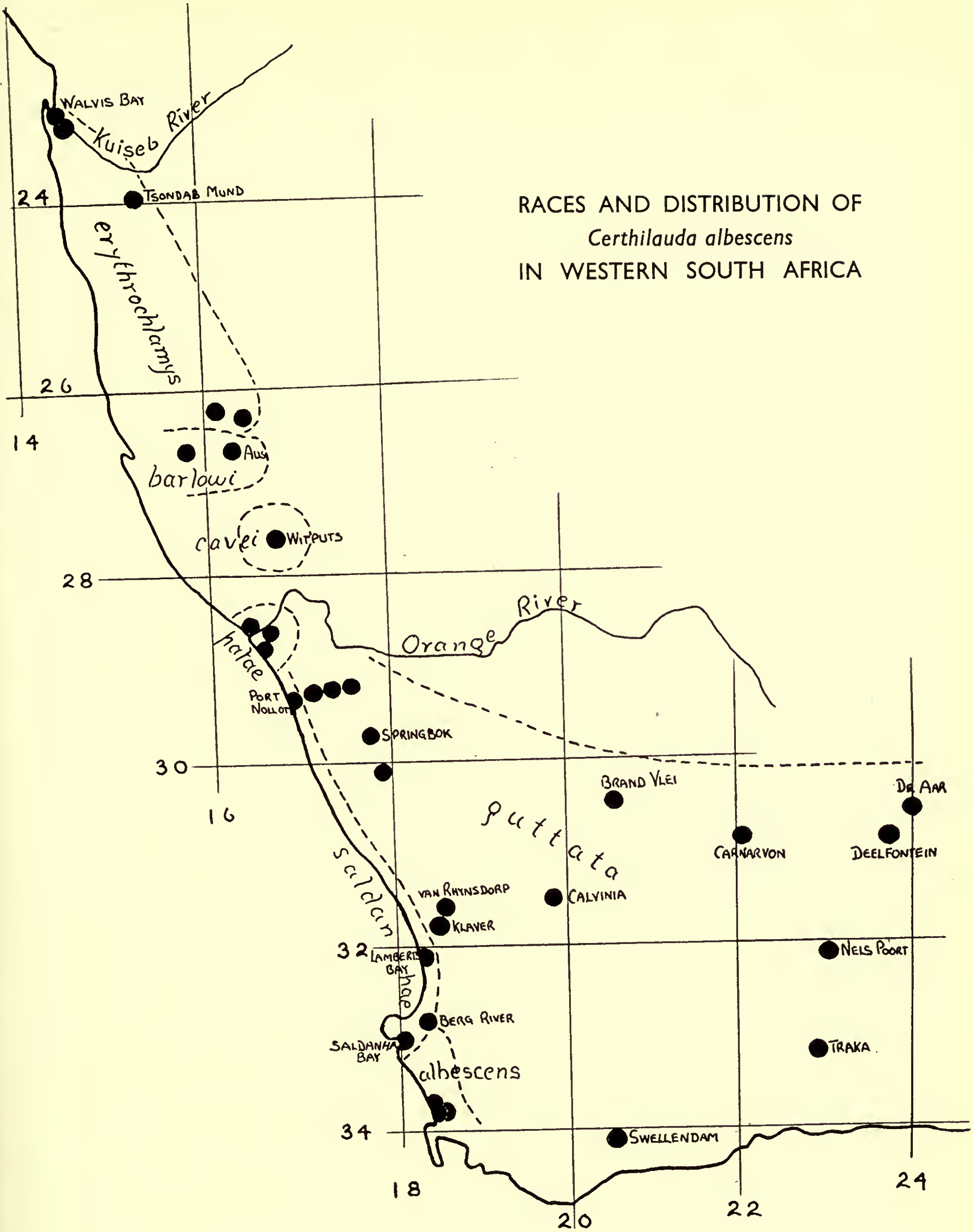
C. a. erythrochlamys

Kuiseb, nr. Walvis Bay	6:9	S.L.–600	Ad.	♂	93	68	20	?	T.M. 24914
,,	6:9	S.L.–600	Ad.	♀	89	62	17	?	T.M. 24915
,,	18:11	S.L.–600	Ad.	♂	91	67	19	27	B.M. 89:9:13:179
,,	?	S.L.–600	Ad.	♂	90	68	19	27	B.M. 73:18:20:218
,,	?	S.L.–600	Ad.	?	89	67	19	28	B.M. 76:5:23:710
,,	18:12	S.L.–600	Ad.	♂	92	67	21	?	T.M. 15104
,,	20:11	S.L.–600	Ad.	?	89	68	17	30	B.M. 76:5:23:709
,,	26:5	S.L.–600	Juv.	♂	87	68	18	29	B.M. 76:5:23:708
,,	?	S.L.–600	Juv.	?	90	68	17	29	B.M. 66:7:19:2
Tsondab Mund	5:3	2,700	Ad.	♂	98	69	20	31	B.M. 1950:50:898
,,	5:3	2,700	Ad.	♂	93	66	20	28	B.M. 1950:50:882
,,	5:3	2,700	Ad.	♂	88	62	19	25	B.M. 1950:50:886
,,	6:3	2,700	Ad.	♂	89	67	20	33	B.M. 1950:50:893
,,	6:3	2,700	Ad.	♂	92	63	20	26	B.M. 1950:50:890
,,	6:3	2,700	Ad.	♂	96	70	19	34	B.M. 1950:50:891
,,	6:3	2,700	Ad.	♂	90	63	20	27	B.M. 1950:50:883
,,	6:3	2,700	Ad.	♂	90	64	20	27	B.M. 1950:50:894
,,	6:3	2,700	Ad.	♂	95	67	21	30	B.M. 1950:50:899
,,	6:3	2,700	Ad.	♂	92	66	20	20	B.M. 1950:50:896
,,	6:3	2,700	Ad.	♂	92	67	20	28	B.M. 1950:50:889
,,	6:3	2,700	Ad.	♀	88	63	18	30	B.M. 1950:50:897
,,	6:3	2,700	Ad.	♀	86	62	18	27	B.M. 1950:50:888
,,	6:3	2,700	Ad.	♀	87	62	18	28	B.M. 1950:50:885
,,	6:3	2,700	Ad.	♀	86	61	18	28	B.M. 1950:50:895
,,	6:3	2,700	Ad.	♀	83	60	18	25	B.M. 1950:50:892
,,	6:3	2,700	Ad.	♀	87	66	18	31	B.M. 1950:50:887
,,	6:3	2,700	Juv.	♀	82	60	16	24	B.M. 1950:50:884
Aus (dunes)	31:1	2,900	Ad.	♂	95	?	20	32	B.M. 1950:50:881
,,	31:1	2,900	Ad.	♂	97	70	20	28	B.M. 1950:50:877
,,	30:7	2,900	Ad.	♂	96	69	20	?	T.M. 20888
,,	29:7	2,900	Ad.	♂	91	69	19	?	T.M. 20885
,,	30:7	2,900	Ad.	♂	93	70	18	?	T.M. (R 598)
,,	30:7	2,900	Ad.	♂	93	71	20	?	T.M. 20893
,,	30:7	2,900	Ad.	♂	91	70	20	?	T.M. 20889

* Type of *Pseudammomanes barlowi* Roberts.

C. a. erythrochlamys (cont.)

Locality	*Date*	*Alt.*	*Age*	*Sex*	*Wing*	*Tail*	*Bill*	*F.P.*	*Reference*
Aus (dunes)	30:7	2,900	Ad.	♂	91	69	19	?	T.M. 20890
,,	31:1	2,900	Ad.	♀	88	?	17	29	B.M. 1950:50:878
,,	31:1	2,900	Ad.	♀	90	69	17	27	B.M. 1950:50:876
,,	31:1	2,900	Ad.	♀	89	70	20	25	B.M. 1950:50:879
,,	31:1	2,900	Ad.	♀	85	60	19	24	B.M. 1950:50:880
,,	30:7	2,900	Ad.	♀	85	66	16	?	T.M. 20896
,,	30:7	2,900	Ad.	♀	85	67	17	?	T.M. 20895
,,	30:7	2,900	Ad.	♀	86	65	18	?	T.M. 20894
,,	30:7	2,900	Ad.	♀	87	68	18	?	T.M. 20892
,,	30:7	2,900	Ad.	♀	83	64	18	?	T.M. 20887


RACES AND DISTRIBUTION OF
Certhilauda albescens
IN WESTERN SOUTH AFRICA
WALVIS BAY
Kuiseb River
TSONDAB MUND
erythrochlamys
barlowi
AUS
cavei
WITPUTS
halae
Orange River
PORT NOLLOT
SPRINGBOK
guttata
BRAND VLEI
DE AAR
CARNARVON
DEELFONTEIN
saldanhae
VAN RHYNSDORP
KLAVER
CALVINIA
LAMBERTS BAY
NELS POORT
BERG RIVER
SALDANHA BAY
TRAKA
albescens
SWELLENDAM
24
26
28
30
32
34
14
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18
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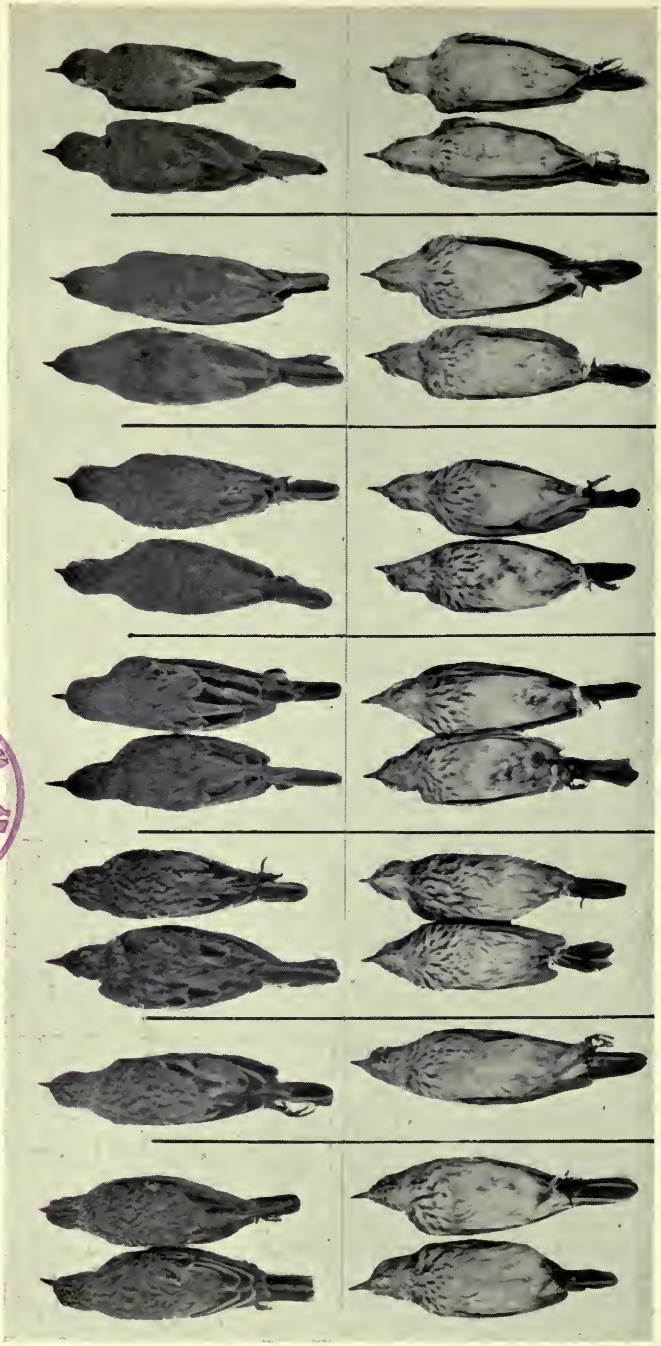
22
24



erythrochlamys

barlowi

cavei

patae

guttata

saldanhae

albescens

VARIATION IN *CERTHILAUDA ALBESCENS*

For distribution of races see map. Changes in pattern are fairly evident and some changes in colour tone can be distinguished

(*a*) Typical desert-edge country about five miles south of Witputs, Huns Mts., with sparse low scrub and prostrate succulents. Red-back Larks (*Certhilauda albescens cavei*) were present in twos; spike-heel Larks (*Certhilauda albofasciata*) in parties of three to five; and Red-cap Larks (*Tephrocorys cinerea*) in restless flocks

(*b*) Shifting sand dunes in the Namib Desert at Tsondab Mund, showing clumps of spiky *Aristida* grass frequented by Red-back Larks (*Certhilauda albescens erythrochlamys*)

PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), *instituted in 1949, is issued in five series corresponding to the Departments of the Museum, and an Historical Series.*

Parts appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

This paper is Vol. 1, No. 12, of the Zoology series.

PRINTED BY ORDER OF THE TRUSTEES OF
THE BRITISH MUSEUM

Issued December 1953 *Price One Pound*

SUBERITES DOMUNCULA (OLIVI): ITS SYNONYMY, DISTRIBUTION, AND ECOLOGY

By MAURICE BURTON

INTRODUCTION

THE names *Suberites domuncula* and *Ficulina ficus* have appeared almost consistently side by side in the literature for nearly 200 years. At times they have been treated as synonyms, and on such occasions *Suberites domuncula* has sometimes been given priority, at other times *Ficulina ficus*. Several major attempts have been made (Lendenfeld (1897), Topsent (1900), and Vosmaer (1933)) to put the histories, synonymies, and affinities of these two species in order. Each has failed for one reason or another. The present work is a comprehensive survey, made in the hope of achieving a reasonable stability.

Since the earliest of the two names, *Ficulina ficus*, is here accepted as a synonym of *Suberites domuncula*, a restatement of its history is a first requisite. In the following pages are included, among other things, notes on individual references to the two species in question, as well as to their numerous synonyms, and this is followed by their arrangement in the usual synonymy list. The first of these tasks was, in fact, done by Vosmaer (1933) very completely, so that to all appearances its repetition is unnecessary. It is, therefore, essential to point out in what manner Vosmaer's work has failed. To begin with, while he justifiably, as I think, regarded *Suberites domuncula* and *Ficulina ficus* as synonyms, and included other names such as *F. lütkenii* within the scope of the species, he went too far. For example, he included *Tethya prunum* Costa, which is quite unrecognizable. He also included *Suberites montiniger* Carter, which belongs more properly to the genus *Pseudosuberites*, and *Suberites concinnus* Lambe, which is a *Hymeniacidon*. Secondly, he did not have the advantage of Topsent's (1933) analysis of the early history of the specific name *ficus*. Thirdly, he included in his list every possible reference to any of these names, and many of them are so trivial that to include them in the synonymy list, already unwieldy, makes it completely overburdened. For example, if an author mentions one of these names merely in passing the name figures in his list of synonyms. I have checked carefully Vosmaer's pages and have eliminated all such trivial entries. Finally, he included certain other references without any justification. These are now given below.

Alcyonium ficus, Hatchett, 1800: 355: this is an account of certain simple chemical tests carried out on a marine organism. There is no information from which the organism could be identified, and nothing to suggest that it is a sponge. From the reactions obtained by the use of some at least of the chemical reagents it would appear to be an Ascidian (probably the Sea-fig as then understood, either *Polyclinum* or *Aplydium*).

Suberites compactus, Crivelli, 1863: 297 (sep. pag. 14), pl. vi, figs. 4–6: this is a

Suberites too inadequately described for the characters of the species to be determined with accuracy.

Halichondria virgultosa. Under this title Vosmaer, 1933: 441 lists Esper (1798), Lamarck (1813), Lamarck (1816), Lamouroux (1816), Blainville (1819), Lamouroux (1824), Lamarck (1836), Johnston (1842), Gray (1848), Duchassaing and Michelotti (1864). None of these authors is dealing with the species later described by Bowerbank as *Hymeniacidon virgultosa* and recognized by subsequent authors as a synonym of *Suberites ficus.*

THE EARLY HISTORY OF *FICULINA FICUS*

The early history of the sponge species, known today as *Ficulina ficus* and known for nearly 200 years under various generic (and often specific) names, is one of unusual confusion. This arose largely from the fact that the 'sea-fig' of the Mediterranean is a sponge, and the 'sea-fig' in English usage is a Tunicate. The shape in both is very similar, and so long as the description of animal species depended on external appearances the mistake was bound to be perpetuated. An attempt was made to straighten out this early confusion by R. Hartmeyer (*J. Mar. Biol. Ass.* **10** (2): 262–282, 1914). This comprehensive paper seems to have escaped the attention of those working upon the taxonomy of sponges, chiefly because it was not included in the Zoological Record under Section III (Porifera or Spongida). According to Hartmeyer's analysis (*l.c.*: 264), the species *ficus* was for the first time 'used in a binomial combination with the generic name *Alcyonium*, so that Pallas must be regarded as the author of that species, which must bear the name *ficus*'. Pallas takes the *Alcyonium tuberosum forma ficus* of Imperato (1599, Ital. p. 599, lat. p. 839), as the first representative of *Ficulina ficus* (Pallas) Autt., and presumably Imperato's description must serve as the type of the species.

Topsent (1933: 27), in analysing the history of *F. ficus*, takes a very different view; but before proceeding to his main argument it is necessary to note what he says concerning *Spongia ficiformis* Poiret, which writers of the late eighteenth and early nineteenth centuries have accepted as a synonym of what we have later known as *Ficulina ficus*. It will be convenient, therefore, to dispose of *Spongia ficiformis*. Here, in tabular form, are Topsent's views:

Alcyonium pulmonaria Ellis and Solander, 1786 = Ascidian.
Spongia ficiformis, Poiret, 1789 = *Petrosia ficiformis* (Poiret). [Topsent points out that the sponge recorded by Guettard (1789, pl. iii), and which Poiret took to represent the same species, was rightly named *Spongia usitatissima* by Lamarck.]
Spongia ficiformis, Gmelin, 1791 = *Petrosia ficiformis* (Poiret).
Spongia ficiformis, Esper, 1794: 282 = *Petrosia ficiformis* (Poiret).
Spongia bulbosum (partim), Esper, 1798, pl. xx, fig. 4 = *Petrosia ficiformis* (Poiret).
Spongia ficiformis, Lamarck, 1816: 47 = *Petrosia ficiformis* (Poiret).
Spongia ficiformis, Lamouroux, 1824 = *Petrosia ficiformis* (Poiret).

Topsent (*op. cit.*) then goes on to remark: 'Aucune confusion n'était permise entre *Spongia ficiformis* Poiret et les animaux qui furent appelés *Alcyonium ficus*. Ce que les auteurs anciens, comme Marsilli et Ellis, ont décrit, et dont Pallas et Linné ont

fait *A. ficus*, était une *Synascidia*, la Pulmonelle figure de de Blainville, et Lamouroux l'a fort bien reconnu, en la rapportant aux genres *Polyclinum* Cuvier ou *Aplydium* Savigny. Mais il semble que l'Éponge lisse, grisâtre à l'extérieur, spongieuse, jaune pâle à l'intérieur, avec oscule au sommet, qu'il prit pour la *Spongia ficiformis* Poiret, était plutôt une *Ficulina*, et ce qu'on appelle *Ficulina ficus* devrait peut-être se nommer *F. ficiformis* (Lamouroux).' In other words, Topsent takes the view that all references to the so-called *Ficulina ficus* prior to Lamouroux (1824) are concerned with either *Petrosia ficiformis* Poiret or an ascidian. If this be so, then *Alcyonium tuberosum forma ficus* of Imperato must belong to one or the other, also. The only opinion opposed to this is the one expressed by Hartmeyer (*l.c.*: 264) that it is 'without doubt a sponge and has been identified by the spongologists as *Ficulina ficus*'. This has practically no value. It certainly is not 'without doubt a sponge'; and if 'the spongologists' have identified it as *Ficulina ficus*, they have merely done so by implication, by copying without question the earlier writers. And these Topsent has shown to be wrong in their identifications.

It is proposed here to accept Topsent's view, which best accords with my re-examination of the evidence. Moreover, as I hope to show, there is good reason to regard the so-called *Ficulina ficus* as a synonym of *Suberites domuncula* (Olivi). Since Olivi's publication antedates the use of *Spongia ficiformis* by fifty years, the ultimate name of the species can no longer be in doubt.

This earlier confusion is, however, paralleled by the subsequent history of the species, though this time in a different sense. *Ficulina ficus* is obviously a close relative of *Suberites domuncula* (Olivi). Indeed, broadly speaking, the latter is a *Ficulina ficus* growing commensally with a hermit crab, and I have long held the opinion that the two species cannot be separated generically and may even be conspecific. It is in order to assess the value of this opinion that the following analysis is undertaken.

CHRONOLOGICAL LIST OF REFERENCES TO *FICULINA FICUS* AND *SUBERITES DOMUNCULA* AND THEIR SYNONYMS, WITH BRIEF NOTES ON THEIR TAXONOMIC VALUE

Alcyonium ficus, Pallas, 1766: 356: the species is established in a binominal combination, and is said to occur in the Mediterranean and on the English coast. [Topsent (1933: 27) accepts Pallas's specimen as an ascidian.]

Alcyonium domuncula, Olivi, 1792: 241: the species is based on the figure 104 in Ginnani 1755. So far as a drawing of this kind can be relied upon, this would appear to be the well-known *Suberites domuncula* of subsequent authors. Presumably Ginnani's figure must be accepted as the holotype of the species. [The doubt implied here results from Topsent's (1900) diagnosis of *Ficulina ficus*. Under this name, as well as under *Suberites domuncula*, he includes specimens growing round mollusc shells inhabited by a *Eupagurus*. In other words, the sponge which everyone else has accepted as *Suberites domuncula* Topsent assigns partly to that species and, in company with the free-growing forms, partly to *Ficulina ficus*. In doing this he gives a very restricted description of *Suberites domuncula* and recognizes its restricted distribution (i.e. to the Mediterranean only). On the other hand, he does not make it precisely clear what differences he finds between the forms he recognizes as *Ficulina*

ficus growing on the *Eupagurus*-shell and *Suberites domuncula*. After studying his words closely it seems that his method of distinguishing between them rests on the characters of the ectosome, in addition to the absence of microscleres. In my opinion these are poor characters to be used in this connexion, but were their use to be upheld by subsequent investigation, then it would be impossible to say if Ginnani's figure represented *Ficulina ficus* or *Suberites domuncula* (*sensu* Topsent (1900) et seq.)]

[*Spongia suberosa*, Esper, 1794: 266, pl. xli, figs. 1–2: has been accepted by some authors as a synonym of *Suberites domuncula* (Olivi), but it has nothing to do with either *Alcyonium ficus* or *A. domuncula*. Ehlers (1870) does not mention it, and although it has the habit of *Halichondria bowerbanki*, its identity is at present uncertain.]

Alcyonium domuncula, Draparnaud, 1801: 169: notes on the living sponge, in which it is assumed that the specimens growing in association with a hermit crab (*Suberites domuncula* Autt.) belong to the same species as those growing on a *Dromia* (i.e. the *Ficulina ficus* Autt.).

Alcyonium domuncula, Renier, 1804: xxv: nothing new.

Alcyonium bulbosum, Esper, 1806: 41: typical examples of Olivi's species are figured and described, but without information on the internal structure.

Alcyonium tuberosum, Esper, 1806, pl. xx: it seems that the author regarded this as a form of the preceding species.

Alcyonium domuncula, Renier, 1807, pl. iii: nothing new.

Spongia domuncula, Bertoloni, 1810: 103: nothing new.

Acyonium [sic] *domuncula*, Lamarck, 1815: 76: nothing new, except to reaffirm that the Mediterranean is the type-locality.

Alcyonium compactum, Lamarck, 1815: 166: this is described by Topsent (1933: 40) as *Suberites domuncula* (Olivi) (partim?).

Alcyonium domuncula, Lamarck, 1816: 394: nothing new.

Alcyonium compactum, Lamarck, 1816: 400: from the Atlantic, appears to be *Suberites domuncula* (Olivi). Spicules not mentioned. (See also Topsent, 1933: 40.)

Spongia domuncula, Lamouroux, 1816: 38: nothing new.

Alcyonium ficus, Lamouroux, 1816: 348: the author draws attention to the confusion between the sponge and the tunicate (see Hartmeyer, *l.c.*). Spicules not mentioned.

Alcyonium compactum, Lamouroux, 1816: 354: from the Atlantic. Spicules not mentioned.

Spongia suberia, Montagu, 1818: 100: although the author gives an excellent description of the sponge, he does not say anything of its spicules. It is growing on univalve shells and is orange-yellow in life. It is clearly the animal generally accepted as *Suberites domuncula* (Olivi).

Spongia domuncula, Bertoloni, 1819: 230: nothing new.

Spongia suberia, Blainville, 1819: 130: nothing new.

Lithumena domuncula, Renier, 1820, pl. iv: nothing new.

Spongia suberosa, Gray, 1821: 361: merely gives a brief summary from Montagu (1818).

Alcyonium domuncula, Martens, 1824: 534: 'Auf dem Schlammgrund längs der westlichen Küste häufig.' Found on hermit crabs and also on the carapace of *Cancer dromia*.

Spongia domuncula, Lamouroux, 1824: 337: gives a summary of the literature to date, adding nothing new.

Alcyonum [sic] *ficus*, Risso, 1826: 381: pear- or fig-shaped, up to 45 mm. long, grows in the 'Regions madréporiques' and is an intense green in life. Spicules not mentioned. Possibly this is the ascidian.

Alcyonum [sic] *domuncula*, Risso, 1826: 380: the author recognizes three varieties—

Var. I. Rubro aurantio, flavo, coeruleo variegato.

Var. II. Albo, poris oblongis, satis magnis et regulariter per superficiem sparsis.

Var. III. Griseo et rubro aurantio variegato. Spicules not mentioned.

[1]*Halichondria suberica*, Fleming, 1828: 522: mainly repeats Gray (1821) and adds, 'I have found this species encrusting Corallines in the Firth of Forth.' The spicules are described as 'fusiform and slightly curved', the colour 'yellow'.

Litumena spugnosa, Renier, 1828, pl. v; nothing new.

Anthelia domuncula, Blainville, 1830: 487: nothing new.

Halichondria suberica, Coldstream, 1830: 235: two specimens from Rothesay Bay, on *Turritella terebra*. No colour notes and the only spicule figured is the tylostyle.

Suberites domuncula, Nardo, 1833: 523; nothing new.

Suberites ficus, Nardo, 1833: 523: nothing new.

Anthelia domuncula, Blainville, 1834: 524: nothing new.

Suberites domuncula, Nardo, 1834: 714: nothing new.

Spongia suberica, Lamarck, 1836: 537: nothing new.

Alcyonium domuncula, Lamarck, 1836: 600: nothing new.

Alcyonium compactum, Lamarck, 1836: 606: nothing new.

Halispongia suberica, Blainville, 1837: 532: nothing new.

Halichondria suberica and *Spongia suberica*, Thompson, 1840: 254: from Strangford and Belfast Loughs, 'investing univalve shells'. Spicules not mentioned.

Halichondria suberica, Bellamy, 1840: 268: records the typical specimens, as well as those 'enveloping stems of sea-weed', from Devon.

Halichondria suberea, Johnston, 1842: 139: adds little that is new.

Halichondria ficus, Johnston, 1842: 144: deep water off Scarborough and Hartlepool; pear-shaped or rounded, often growing on shells; greyish-white; no mention of microscleres.

Halichondria domuncula, Gray, 1848: 13: nothing new.

Halichondria ficus, Gray, 1848: 15: nothing new.

Halichondria suberea, Bowerbank, 1858: 287: gives the first good drawing of the megasclere.

Halichondria ficus, Bowerbank, 1858: 298: the strongylote microsclere is figured.

Halichondria compacta, Lieberkühn, 1859: 520: on *Buccinum* and *Murex* inhabited, usually, by *Pagurus callidus*; colour of red-lead; spicules tylostyli.

Halina suberea, McAndrew, 1861: 235: nothing new.

[1] This seems to contain the first mention of spicules, but megascleres only are mentioned. The first mention of microscleres is in Bowerbank, 1858.

Halina ficus, McAndrew, 1861: 235: nothing new.

Hymeniacidon subereum, Bowerbank, 1862: 1111: nothing new.

Halichondria ficus, Bowerbank, 1862: 1129: 'An elongated form of *Halichondria ficus* has also been again described as *H. virgultosa*' (i.e. by Johnston, 1842).

Suberites domuncula, Schmidt, 1862: 67: largely reiterates Lieberkühn's notes, but adds that there are two varieties, one from Quarnero which 'hat vorwiegend stumpfe Nadeln' (? = microstrongyla), and the other, from Zlarin which 'hatte eine ganz prächtige Färbung, indem sie auf weissem und rothem Grunde lazurblau gezeichnet war'. Schmidt also described the species as common and well known.

Suberites domuncula, Crivelli, 1863: 286: notes and coloured pictures.

Suberites domuncula, Kölliker, 1864: 71: nothing new.

Halichondria ficus, Bowerbank, 1864: 222 [also as *Hymeniacidon ficus* p. 244]: the centrotylote microstrongylote is figured, otherwise nothing new.

Hymeniacidon suberea, Bowerbank, 1864: 231: nothing new.

Halichondria (*Hymeniacidon*) *suberea*, Hughes, 1866: 86: notes on the development of the gemmules.

Hymeniacidon virgultosa, Bowerbank, 1866: 193: a number of specimens from the Dogger Bank, erect (?), subcylindrical and substipitate, the base enclosing a *Fucus*, Zoophyte, or *Dentalium*, and ranging from 2¾ in. to 15 in. in length and up to ½ in. diameter. The colour, dried, is light buff-yellow.

Bowerbank's specimens do not belong to the same species as [1]*Halichondria virgultosa* Johnston, which is apparently a *Suberites* sp. but of different habit; nor, it may be presumed, to the *Spongia virgultosa* of Lamarck and Lamouroux.

Hymeniacidon suberea, Bowerbank, 1866: 200: gives 'Locality.—The whole of the British coast', and 'colour.—Alive, yellow or orange; dried, yellow or brown'. His extensive notes show that he had difficulty in distinguishing between this species and *Suberites carnosa* on the basis of their respective spicules, and between *Hymeniacidon suberea* and *Ficulina ficus* on the basis of habitus. He found the species surrounding shells 'of Turbo, Fusus and other univalves', 'based on a Dentalium, a Vermetus, or some other equally ill-chosen locality', as 'large massive specimens', or 'partially enveloping a shell of a Fusus, the mollusc evidently alive at the time'. He also records 'a specimen as large as a hen's egg, attached by a broad base to the side of St. Katherine's Rock, at Tenby, between high and low water mark'. Bowerbank sees in the 'minute inflato-cylindrical' spicules (i.e. microstrongyla) the chief means of distinguishing *Ficulina ficus* from *Hymeniacidon suberea*.

Hymeniacidon ficus, Bowerbank, 1866: 206: specimens from Scotland, Northumberland, and Hebrides, coloured grey, white, or russet red when alive. The specimens ranged from encrusting on a *Pecten* shell, covering 'a small univalve shell precisely after the manner of *H. suberea*', to bulbous or fig-shaped. Clearly Bowerbank has used the presence of microstongyla as a distinctive character, but finds some difficulty in distinguishing between *H. ficus* and *H. suberea* on the grounds of habitus.

Halichondria farinaria, Bowerbank, 1866: 269: is encrusting on *Pecten opercularis*, from Belfast Bay, Firth of Clyde and off Hastings, at 5 fathoms. It is scarlet or

[1] See last paragraph of the introduction (above).

reddish-orange in life and seems to have been found in fair numbers in the dredges. Microstrongyla are present.

Reniera ficus, Schmidt, 1866: 16: it is (erroneously) suggested that this is a synonym of *R.* (*Hymeniacidon*) *caruncula*.

Suberites farinaria, Schmidt, 1866: 16: nothing new.

Reniera virgultosa, Gray, 1867: 518: nothing new.

Halichondria farinaria, Gray, 1867: 519: nothing new.

Suberites suberea, Gray, 1867: 523: nothing new.

Ficulina ficus, Gray, 1867: 523: nothing new.

Suberites domuncula, Marcusen, 1867: 358: from the Black Sea.

Hymeniacidon subereus, Norman, 1868: 331: from the Shetlands. 'Not so common as *M.* [sic] *ficus*, to which it is very closely allied.'

Hymeniacidon ficus, Norman, 1868: 331: from the Shetlands. 'Common, coating univalve shells, and generally inhabited by hermit crabs.'

Suberites suberia, Parfitt, 1868: 12: common along the Devon coast. No other information.

Suberites domuncula, Schmidt, 1868: 14: gives a faunistic record for Algeria, without other comment.

Halichondria farinaria, Bowerbank, 1868: 124: nothing new.

Hymeniacidon suberea, Wright, 1869: 53: nothing new.

Halichondria farinaria, Wright, 1869: 54: nothing new.

Hymeniacidon ficus, Norman, 1869: 297: from Oban.

Halichondria suberea, Carter, 1870: 82: notes on the gemmules. Carter considers the sponge has the property of dissolving shells and places it in the Clioniadae (of Gray).

Suberites heros, Schmidt, 1870: 46: a sponge from the Antilles, with the habitus of *S. domuncula*, '1½ Faust gross', and spicules ranging from styli to subtylostyli or tylostyli.

Suberites lütkenii, Schmidt, 1870: 47: a new species, with microspined microscleres is described, from Denmark and Greenland.

Suberites domuncula, Schmidt, 1870: 76: nothing new.

Suberites ficus, Schmidt, 1870: 76: nothing new.

Hymeniacidon virgultosa, Schmidt, 1870: 76: nothing new.

Hymeniacidon suberea, Schmidt, 1870: 76: the author thinks this the same as *Suberites domuncula*.

Halichondria farinaria, Schmidt, 1870: 77: nothing new.

Alcyonium domuncula, des Moulins, 1872: 342: the taking is recorded of this sponge in large numbers in fishermen's nets in the Gulf of Lyons. The hermit crab is extracted and used as bait. A synonymy list of the species is given.

Suberites lütkenii, Möbius, 1873: 148: nothing new.

Hymeniacidon ficus, MacIntosh, 1874: 143: specimens, growing on *Dentalium entalis*, 'frequent on muddy ground'.

Suberites lütkenii, Schmidt, 1874: 429: nothing new.

Hymeniacidon virgultosa, Bowerbank, 1874: 89: more specimens examined since 1866, growing on univalve shells, and on a flat mass 'so like *H. suberea* that it is only

by microscopical examination that it can be separated from that species'. Microstrongyla present.

Hymeniacidon suberea, Bowerbank, 1874: 91: a specimen, from the Shetlands, in about 70 fathoms, of massive form enclosing a shell.

Hymeniacidon ficus, Bowerbank, 1874: 92: more specimens, massive or ficiform, growing on bivalve shells or around univalve shells, from Tenby and the Island of Harris. Microstrongyla present.

Halichondria farinaria, Bowerbank, 1874: 177: a small encrusting form, on *Pecten opercularis*, from Strangford Lough. Microstrongyla present.

Suberites domuncula, Schmidt, 1875: 115: specimens from Solsvig, Peterhead, and Portobello, littoral to 50 fathoms. No other information.

Suberites ficus, Schmidt, 1875: 116: a specimen from east of Bamborough, in 36 fathoms on a bottom of sand and small stones. No other information.

Halichondria suberea, Carter, 1875: 197: nothing new.

Halichondria ficus, Carter, 1875: 197: nothing new.

Suberites lütkenii, Lütken, 1875: 190: nothing new.

Suberites domuncula, Carter, 1878: 157: nothing new.

Suberites domuncula, Krukenberg, 1879: 66: notes on the physiology.

Suberites domuncula, Krukenberg, 1879: 705: notes on the physiology.

Suberites domuncula, Krukenberg, 1880: 37: notes on the physiology.

Suberites montalbidus, Carter, 1880: 256: preliminary notice of a sponge from Barents Sea having centrotylote microxea for microscleres.

Suberites domuncula, Czerniawsky, 1880: 236: from the Black Sea.

Suberites domuncula, Leslie and Herdman, 1881: 60: nothing new.

Halichondria suberea, Carter, 1881: 255: nothing new.

Suberites domuncula, Vosmaer, 1881: 4: nothing new.

Hymeniacidon virgultosus, Bowerbank, 1882: 83: nothing new.

Hymeniacidon subereus, Bowerbank, 1882: 88: nothing new.

Hymeniacidon ficus, Bowerbank, 1882: 89: abundant in Shetlands, Durham (Coralline zone), and specimens also from Oban ('on a pebble between tide-marks') and Westport, Co. Mayo.

Halichondria farinaria, Bowerbank, 1882: 114: nothing new.

Suberites domuncula, Klebs, 1882: 295: 'Der Schwamm . . . lebt stets auf Schneckenschalen, in denen ein *Pagarus* lebt; er umwächst die Mündung der Schale, so dass der Krebs häufig ganz eingeschlossen wird und sterben muss.'

Halichondria suberia, Carter, 1882: 353: nothing new.

Halichondria ficus, Carter, 1882: 353: nothing new.

Suberites montalbidus, Carter, 1882: 353: a specimen from Barents Sea, with microstrongyla and faintly spined microxea, both centrolylote.

Suberites domuncula, Graeffe, 1882: 318: from Trieste, with notes on ecology.

Suberites domuncula, Vosmaer, 1882: 20: nothing new.

Suberites sp., Vosmaer, 1882: 32: a specimen from the Arctic approximating to *S. montalbidus*.

Suberites domuncula, Carter, 1883: 30: 150 specimens dredged 20 miles off Budleigh Salterton, growing on *Turritella* and *Buccinum*, with *Pagurus* or an

annelid inside, had incorporated much debris from the sea-bed in their substance.

Suberites domuncula, Marion, 1883: 65: notes, especially on its abundance, of the sponge off the Marseilles coast.

Suberites domuncula, Vosmaer, 1884: 121: nothing new.

Suberites domuncula, Vosmaer, 1885: 332: nothing new.

Suberites montalbidus, Fristedt, 1885: 19: records from the Swedish coast, in 75 m., of sponges with the spiculation shown by Carter (1882).

Suberites ficus, Fristedt, 1885: 20: specimens from coast of Sweden, pale red in life, from various depths. Microstrongyla present.

Suberites virgultosa, Fristedt, 1885: 21: five specimens from the Swedish coast, from unknown depths. Microstrongyla present.

Suberites suberia, Higgin, 1886: 86: nothing new.

Suberites domuncula, Vosmaer, 1886: 86: nothing new.

Suberites domuncula, Vosmaer, 1886: 457: nothing new.

Suberites lütkenii, Marenzeller, 1886: 3: the species is regarded as identical with *S. montalbidus*.

Suberites montalbidus, Fristedt, 1887: 428: a number of specimens from Bering Sea and Bering Strait, the Siberian Arctic Ocean, Beaufort's Sea, Kara Sea, Barents Sea, and west of Greenland, in 2 to 40 fathoms, all having centrotylote microstrongyla and faintly spined microxea.

Suberites domuncula, Ridley and Dendy, 1887: xlv: notes on histology.

Suberites domuncula, Sollas, 1888: 415: notes on the structure of the skeleton.

Suberites compactum, Topsent, 1888: 134: the sponge recorded by Lamouroux is said to be the equivalent of '*Spongia domuncula* (*Suberites ficus*)'.

Suberites domuncula, Topsent, 1888: 134: nothing new.

Suberites ficus, Topsent, 1888: 134: is said to have the same Amphipod symbiont as *S. domuncula*.

Suberites suberea, Topsent, 1888: 150: dredged at Luc and le Quihoc, it is encrusting and a deep orange.

Suberites ficus, Topsent, 1888: 150: not common at Luc, it has the same habitat as *S. suberea*, and though orange-red as a rule, it is subject to 'décolorations partielles' and is often yellow or greyish. The surface is often perforated where an Amphipod, *Tritacta gibbosa*, is living.

Suberites domuncula, Lendenfeld, 1888: 65: similar in habitat to the European forms, but although enclosing a crab the Australian forms do not contain shell with *Pagurus*. Colour bright yellow. Without microstrongyla.

Suberites domuncula, Dendy 1889: 23: nothing new.

Suberites domuncula, Lendenfeld, 1889: 798: is usually carried on the carapace of a *Dromia*.

Suberites suberea, Hanitsch, 1889: 158: from Liverpool district.

Halichondria farinaria, Topsent, 1889: xxxviii: nothing new.

Suberites domuncula, Topsent, 1890: 232: nothing new.

Suberites domuncula, Topsent, 1890: 232: 'partout dans la Manche.'

Suberites suberea, Topsent, 1890: 202: from Luc.

Suberites ficus, Topsent, 1890: 202: from Luc.

Suberites farinaria, Topsent, 1890: 203: nothing new.

Suberites domuncula, Hanitsch, 1890: pp. 195, 214: gives records for the estuary of the Mersey, north Wales, Isle of Man, and Puffin Island, and declares that it may be found growing on bivalve shells and other substrata, as well as on univalve shells inhabited by hermit crabs.

Suberites ficus, Hanitsch, 1890: 195: from north Wales.

Suberites domuncula, Hanitsch, 1891: 218: several specimens from 10 fathoms off the west coast of Ireland. Hanitsch draws attention to the presence of microstrongyla, and to so many previous authors having missed them.

Suberites ficus, Hanitsch, 1891: 219: two specimens from off the west coast of Ireland, in 5 to 15 fathoms.

Suberites ficus, Topsent, 1891: 529: dredged at Roscoff.

Suberites ficus, Topsent, 1891: 127: from Arcachon.

Suberites ficus, Topsent, 1891: 14: two specimens from between Dakar and Rufisque, at 25 m., on muddy sand, with microstrongyla that lack a centrum.

Suberites domuncula, Topsent, 1891: 15: a single littoral specimen from Dakar.

Suberites domuncula, Topsent, 1891: 15: from Dakar.

Suberites ficus, Topsent, 1891: 127, 129: from Arcachon.

Suberites ficus, Topsent, 1891: 529: from Roscoff.

Suberites domuncula, Hanitsch, 1891: 218: several specimens from the west coast in 10 fathoms. He mentions the presence of centrotylote microstrongyla.

Suberites ficus, Hanitsch, 1891: 219: from the west coast of Ireland in 5 to 15 fathoms.

Suberites latus, Lambe, 1892: 71: four specimens from British Columbia, lobo-massive, up to 60 mm. across, yellowish-brown in spirit, but without microstrongyla. Lambe (1893: 126) agrees this is conspecific with *S. suberea* (= *ficus*).

Suberites domuncula, Holt, 1892: 239: from Blacksod Bay, in 7 fathoms, on fine sand.

Suberites ficus, Topsent, 1892: 128: four specimens from the Bay of Biscay in depths varying from 63 to 180 m. No mention is made of colour or the presence of microstrongyla.

Suberites ficus, Levinsen, 1893: 410: numerous specimens from the Kattegat. According to the figures given, the spiculation resembles closely that of *S. montalbidus*.

Suberites farinarius, Levinsen, 1893: 412: a specimen from the Kattegat, with centrotylote microscleres.

Suberites montalbidus, Levinsen, 1893: 413: three specimens from the Kattegat in 17½ fathoms, showing the spiculation described by Carter (1882).

Suberites domuncula, Celesia, 1893: 1: extensive notes on the relation between the form of the sponge and the presence of the hermit crab.

Suberites ficus, Topsent, 1894: 21: from the Pas-de-Calais. *Halichondria farinaria* and *H. virgultosa* are regarded as synonyms.

Suberites domuncula, Topsent, 1894: 23: from the Pas-de-Calais.

Suberites suberea, Lambe, 1894: 126: nearly sixty specimens from Alaska. '. . . the

flesh-spicules are present in the majority of cases, but absent in a few; in some specimens they occur in great abundance, in others only one or two were seen. Evidently the presence or absence of the flesh-spicules cannot be considered of specific value.'

Suberites montalbidus, Lambe, 1894: 127: a single example, 25 mm. across, from the Aleutians, with microscleres as described by Carter (1882).

Suberites ficus, Weltner, 1894: 327: four specimens from the North Sea, including the Dogger Bank, from depths varying from 32 to 50 m. No colour records are given and microstrongyla are not mentioned.

Suberites virgultosa, Hanitsch, 1894: 177: nothing new.

Suberites domuncula, Hanitsch, 1894: 177: nothing new.

Suberites ficus, Hanitsch, 1894: 177: nothing new.

Suberites farinarius, Hanitsch, 1894: 179: nothing new.

Suberites heros, Weltner, 1894: 328: suggests the identity of this species with *S. ficus*.

Suberites suberea, Lambe, 1895: 126: records 60 specimens from Alaska, and points out (p. 127) that his *S. latus*, from Vancouver Island, is identical with *S. suberea*.

Suberites montalbidus, Lambe, 1895: 127: from Alaska.

Suberites domuncula, Heider, 1895: 283: nothing new.

Suberites ficus, Lambe, 1896: 193: two dried specimens from Nova Scotia, with microstrongyla, the one growing on a *Pecten tenuicostata* shell, the other on the inside of a shell of *Cyprina*.

Suberites ficus, Topsent, 1896: 275: several specimens from the Bay of Biscay at 140 to 400 m.

Suberites ficus, Topsent, 1896: 118: from Quiberon (Atlantic coast of France).

Ficulina ficus, Lendenfeld, 1896: 94: an extensive review of previous knowledge, with little additional information.

Suberites domuncula, Lendenfeld, 1896: 118: a review of previous knowledge, with little additional information.

Ficulina ficus, Topsent, 1898: 129: nothing new.

Suberites heros, Thiele, 1898: 37: is probably identical with *S. domuncula*.

Suberites domuncula, Thiele, 1898: 37: the author differentiates between *S. domuncula*, without microstrongyla, and *S. subereus*, with microstrongyla (but see Lambe, 1894: 126).

Suberites lütkenii, Thiele, 1898: 38: is probably identical with *S. domuncula*.

Suberites subereus, Thiele, 1898: 38: several specimens from Japan, some enclosing shells, examined dry. Microstrongyla present.

Suberites placenta, Thiele, 1898: 39: a depressed cake-shaped sponge from Japan, dry, with tylostyli and microstrongyla.

Suberites sericeus, Thiele, 1898: 39: dry incrustations from Japan on a *Pecten* and a gastropod shell, without microstrongyla, probably represent either *S. ficus* or *S. domuncula*.

Prosuberites inconspicuus, Thiele, 1898: 40: a dry encrusting specimen from Japan, in 100 fathoms, with tylostyli as in Thiele's specimen of *Suberites subereus*, but without microstrongyla, is probably a young *S. domuncula*.

Prosuberites exiguus, Thiele, 1898: 40: two dried encrusting specimens from Japan, very like *P. inconspicuus*, probably represent young forms of *Suberites domuncula*. They are without microstrongyla.

Ficulina ficus, Topsent, 1899: 105: recorded for the coast of Belgium without further details.

Ficulina ficus, Topsent, 1900: 203: in a review of the species the author increases the confusion by using the presence or absence of the microstrongyla as a basis for the specific distinction. Consequently, under *F. ficus* are included all forms having microscleres regardless of the external form.

Suberites lütkenii, Topsent, 1900: 213: is regarded as a variety of *Ficulina ficus*.

Suberites domuncula, Topsent, 1900: 225: the species is interpreted in a narrow sense, depending almost entirely on the absence of microscleres.

Suberites suberea, Lambe, 1900: 161: nothing new.

Suberites ficus, Lambe, 1900: 161: nothing new.

Suberites montalbidus, Lambe, 1900: 162: nothing new.

Suberites montalbidus, Lambe, 1900: 24: from Hudson Bay and Strait.

Suberites montalbidus, Lambe, 1900: 277: nothing new.

Suberites domuncula, Cotte, 1901: 1: chemico-physiological notes.

Suberites domuncula, Cotte, 1901: 95: physiological notes.

Suberites domuncula, Bidder, 1902: 380: the author suggests that texture is a result of ecological conditions.

Ficulina ficus, Rousseau, 1902: 18: the author treats *Suberites domuncula* as a synonym of this species and records it from the coast of Belgium.

Suberites heros, Thiele, 1905: 415: nothing new.

Suberites domuncula, Thiele, 1905: 416: nothing new.

Suberites domuncula, Swartschewsky, 1905: 35: the species is recorded from the Black Sea.

Suberites heros, Swartschewsky, 1905: 35: is accepted as a synonym of *S. domuncula*.

Suberites montalbidus, Swartschewsky, 1906: 318: from the White Sea.

Ficulina ficus, Lundbeck, 1907: 558: 'Trois petits exemplaires pédunculés'. No other information.

Ficulina ficus, Lundbeck, 1909: 453: one specimen, 100 mm. across, from East Greenland, in 25–40 fathoms. No other details.

Ficulina ficus, Stephens, 1912: 21: the author accepts the identity of *Suberites domuncula* with this species and gives records for south-west Ireland from between tide-marks down to 8 fathoms. Massive specimens were found in littoral zone, and dredged specimens were growing on *Pecten* or on gastropod shells containing *Eupagurus cuanensis*.

Ficulina ficus, Topsent, 1913: 25: from Norway; a score of specimens 'enveloppant des coquilles et abritant des Pagures'.

Ficulina lütkenii, Topsent, 1913: 25: from Norway.

Ficulina ficus, Müller, 1913: 291: the author treats *Suberites domuncula* and *Ficulina ficus* as one and the same thing. He gives notes on the gemmules in 373 specimens from the Barents Sea, taken in 60–67 m. in August. Of this total 261 were on bivalve shells, 6 on gastropod shells, and 36 on stones. The rest were

without point of attachment. Colour notes are not given, but microstrongyla are figured.

Ficulina ficus, Stephens, 1915: 35: the author lists many records from Ireland.

Suberites domuncula, Babić, 1921: 14: merely records the species for the Adriatic.

Suberites domuncula, Babić, 1922: 272: several specimens, on *Turritella*, from the Adriatic, the largest 90 mm. in diameter. No colour records are given and no mention made of microstrongyla.

Ficulina ficus, Ferrer, 1922: 269: nothing new.

Suberites domuncula, Topsent, 1925: 633: records the species as common at Naples and varied in colour. He gives the opinion that the specimens at Naples do not attain such large proportions as those at Banyuls.

Suberites domuncula, Dembowska, 1926: 163: an account of the habits of *Dromia vulgaris* and its use of the sponge.

Ficulina ficus, Broch, 1927: 5: from Norway, Lindesness, in 20–24 m., growing on black mud. No other information.

Ficulina ficus, Topsent, 1928: 156: specimens recorded from the Bay of Biscay and the Azores, from depths of 130 to 1,331 m. No colours are mentioned, and as to external form the author merely says, of the specimens from Stn. 3660, that they are enveloping the shells of Gastropods. As to the specimen from a depth of 1,331 m., the author speaks of it as 'bien typique, à microstrongyles centrotylotes, lisses, abondants'.

Suberites domuncula, Topsent, 1928: 154: the species is recorded from off Toulon, in 20 m., with no other comment.

Ficulina ficus, Arndt, 1928: 33: treats this species and *Suberites domuncula* as synonyms, and summarizes the characters of the species.

Ficulina ficus, Hentschel, 1929: 928: nothing new.

Ficulina lütkenii, Hentschel, 1929: 928: nothing new.

Suberites domuncula, Burton, 1932: 201: a single specimen from Japan, in 10 fathoms, enclosing a hermit crab. The synonymy of this species and *Ficulina ficus* is suggested.

Suberites domuncula, Vosmaer, 1933: 426: a very extensive review of the species, but more confusion is caused by ascribing too wide limits to the species.

Suberites domuncula, and *Ficulina ficus*, Burton, 1934: 313: the two species are compared.

Ficulina lütkenii, Burton, 1934: 14: from East Greenland, at 3–191 m.

Suberites domuncula, Topsent, 1934: 14: from Monaco.

Ficulina ficus, Topsent, 1934: 16: in his specimens from Monaco, Topsent finds the occurrence of microstrongyla variable. In 'des cas embarrassants' he succeeded 'par grattage du pourtour de l'oscule' in finding a few in specimens which should otherwise be assigned to *Suberites domuncula*.

Suberites domuncula, Arndt, 1935: 39: a summary of our knowledge of the species is given.

Suberites ficus, Arndt, 1935: 39: in a summary of our knowledge of the species, Arndt returns to the orthodox method of distinguishing between this species and *S. domuncula* (i.e. basing his distinction solely on the presence or absence of microstrongyla).

Suberites domuncula, Burton, 1935: 77: from the Sea of Japan, in 10–35 m.

Suberites domunculus, de Laubenfels, 1949: 20: from Wood's Hole. The author appears to accept the identity of *Ficulina ficus* with *Suberites domuncula.*

It would seem unnecessary to go into such minute detail, but for the confusion which has arisen independently of that caused by the early authors. In the main, authors since Lamouroux have treated as *Ficulina ficus* those specimens, with tylostyli and centrotylote microstrongyla, growing with their bases implanted on a shell or other substratum. They have treated as *Suberites domuncula* any specimen of comparable structure completely enclosing a gastropod shell containing a hermit crab. Yet both species have the same two categories of spicules arranged in the same way, have a similar texture and colour, and have a similar geographical range and bathymetric distribution. These things have been recognized by Martens, Stephens, Arndt, and Müller, who have regarded the two forms as conspecific. Admittedly these four authors form a minority, but it is worth recalling that Müller examined 373 specimens in a single investigation, and Stephens, whose work is of a uniformly high standard, must have handled more than this number in the course of a few years. I am the more inclined to accept their verdict since it coincides with my own (1934) arrived at independently. Against this we must set the views of many authors of limited experience, as well as those of Lendenfeld and, more especially Topsent, both workers of wide experience. Moreover, Arndt (1935) subsequently reverted to this view, apparently. The value of Lendenfeld's opinion can, however, be judged from his most extensive work on these two supposed species. In 1897 he set forth their characters in great detail and his figures show in each case that he was dealing with specimens enclosing a gastropod shell containing a hermit crab. In other words, he clearly had accepted the presence or absence of the microstrongyla as of specific importance. In Topsent's (1900) main study of the two supposed species it is evident that he has adopted a similar plan. Lendenfeld, at least, seems to have based his action on Bowerbank (1866), who, while admitting the difficulty of distinguishing between the *Ficulina ficus* and *Suberites domuncula*, adopted the presence or absence of microstrongyla for their separation. It will be possible to show, not only that the presence or absence of the microstrongyla has no taxonomic value, but that at the most these two supposed species are probably no more than ecological varieties, if indeed there is that much separation.

The history of the microstrongyla is quite remarkable. Although *Suberites domuncula* was first described in 1792, it was not until 1828 that any mention of its spicules is made. Then Fleming described them as 'fusiform and slightly curved'. It was not, however, until 1834 that Coldstream figured a recognizable tylostyle. These are, however, the megascleres. No mention was made of the microscleres until much later, when Bowerbank (1858, p. 298) mentioned the finding of an 'inflato-cylindrical' in *Halichondria ficus*, and figured what is now called the centrotylote microstrongyle on pl. xxiv, fig. 25. In 1862 Schmidt wrote of 'stumpfe Nadeln', which may or may not refer to microstrongyla, and it was left to Lambe (1894), who examined nearly sixty specimens to show that they are present in *Suberites domuncula* as well as in the so-called *Ficulina ficus*. He found those microscleres present in varying numbers. In

only a few cases did he find them lacking in the typical *Suberites domuncula*. He presumed, therefore, that 'the presence or absence of the flesh-spicules cannot be considered of specific value'. Experience leads me to endorse Lambe's view; and we may be reasonably sure that this is true also for workers such as Stephens and, possibly, Arndt.

Another distinction that has been made between *Suberites domuncula* and *Ficulina ficus* is that the first is typically orange or red and the second typically green or greenish. Nobody has specifically stated this in print, but I have found it a prevalent opinion. If we summarize the colour records from the chronological list of references given above, we find that there is little to choose between them. Considering the number of times the two species have been referred to in the literature, colour records are meagre. They may be summarized as follows:

Suberites domuncula: orange-yellow (Montagu); orange-red, white, grey and orange-red (Risso); yellow (Fleming); yellow or orange (Bowerbank); colour of red-lead (Lieberkühn); white and red with blue patches (Schmidt); deep orange (Topsent); bright yellow (Lendenfeld); varied in colour (Topsent); usually orange, often white or white marbled with red and blue (Topsent); orange-yellow (Lendenfeld).

Ficulina ficus: greyish-white (Johnston); scarlet or reddish-orange (Bowerbank); pale red (Fristedt); usually orange-red, often greyish or yellow (Topsent); orange-yellow (Lendenfeld).

It seems there is little to choose between the two forms in the matter of colour.

The external form appears to have constituted a further barrier to recognizing the identity of *Ficulina ficus* with *Suberites domuncula*. In the former it is typically fig- or pear-shaped, with more or less of a stout peduncle, but variations are recognized up to the long, almost strap-shaped sponges seen in Bowerbank's *Halichondria farinaria*. The typical form in *Suberites domuncula* is oval or spherical with, on one side, an opening showing the presence of a hermit crab. What has not been recognized are the various intermediates between the two, and the fact that the association between the *Suberites* and the hermit crab is not a specific commensalism. To take the form first, *Ficulina ficus* has been recorded as growing on seaweeds and on bivalve and gastropod shells. It will, from my own observations, also grow on pebbles or rock surfaces. It may be encrusting, cushion-shaped, irregularly massive, lobose, ficiform, or elongated (farinaria-form). The base may surround to a varying extent the object to which it is attached. *Suberites domuncula* is normally encrusting, or spherical or subspherical, but may also be irregularly massive or lobose. The absence of the ficiform or elongated shape is almost certainly the result of the shell, on which the sponge is seated, being in a state of more or less continuous motion due to the presence in it of a hermit crab.

That there is no specific commensalism between *Suberites domuncula* and a hermit crab may be shown by the following:

The sponge has been found associated with:

1. A wide variety of gastropod shells, which may often be without a hermit crab;
2. Several different species of *Eupagurus*;

3. The carapace of a *Dromia*;
4. A *Fusus*, with the mollusc still alive.

The evidence is markedly in favour of following the opinion of Arndt, Stephens, and others. There is, however, one point on which a reasonable doubt may be felt. This concerns the nature of *Suberites montalbidus* Carter. In the holotype its microscleres are microspined and centrotylote microxea in addition to the smooth centrotylote microstrongyla. It seems, however, that this sharp distinction is not always maintained. Fristedt (1887), for example, also found both kinds in his Arctic specimens, but the microxea were but faintly spined and apparently not centrotylote. It is significant, nevertheless, that the recorded specimens of *S. montalbidus* are from Barents Sea (Carter), Bering Sea and Strait, the Siberian Arctic, Kara Sea, Barents Sea, and west of Greenland (Fristedt), Barents Sea (Levinsen), and the Aleutians (Lambe), so that there is reasonable ground for suspecting that it constitutes a northern form. In the northern limits of its range *Suberites domuncula* (+*Ficulina ficus*) has also been recorded from Alaska, East Greenland, and Barents Sea. There is not, therefore, a clear line of geographical separation between it and *S. montalbidus*, and added to this Fristedt (1885) has recorded the latter from the coast of Sweden also. It may be that authors, such as Stephens, who have wide experience of *S. domuncula*, and have accepted *S. montalbidus* as one of its synonyms, have found microspined microxea in southern individuals and have not considered it sufficiently important to draw attention to the fact. Under the circumstances, it would be better to follow the example set by experienced authors and regard *S. montalbidus* as a synonym of *S. domuncula*, at least for the present.

REVISED LIST OF SYNONYMS OF *SUBERITES DOMUNCULA*, WITH A DESCRIPTION OF THE SPECIES, INCLUDING ITS DISTRIBUTION

Suberites domuncula (Olivi)

Alcyonium domuncula, Olivi, 1792: 241; Draparnaud, 1801: 169; Renier, 1804: xxv; *A. bulbosum*, Esper, 1806: 41; *A. tuberosum*, *idem*, *l.c.*, pl. xx; *A. domuncula*, Renier, 1807: pl. iii; *Spongia domuncula*, Bertoloni, 1810: 103; *Acyonium* [sic] *domuncula*, Lamarck, 1815: 76; *Alcyonium compactum*, *idem*, *l.c.*: 166; *A. domuncula*, *idem*, 1816: 394; *A. compactum*, *idem*, *l.c.*: 400; *Spongia domuncula*, Lamouroux, 1816: 38; *Alcyonium ficus* (partim?), *idem*, *l.c.*: 348; *A. compactum*, *idem*, *l.c.*: 354; *Spongia suberia*, Montagu, 1818: 100; *S. domuncula*, Bertoloni, 1819: 230; *S. suberia*, Blainville, 1819: 130; *S. suberosa*, Gray, 1821: 361; *Alcyonium ficiforme* (partim?), Lamouroux, 1821: 29; *A. domuncula*, Martens, 1824: 534; *Spongia domuncula*, Lamouroux, 1824: 337; *Alcyonium domuncula*, Risso, 1826: 380; *Halichondria suberica*, Fleming, 1828: 522; Coldstream, 1830: 235; *Anthelia domuncula* Blainville, 1830: 487; *Suberites ficus*, Nardo, 1833: 523; *S. domuncula*, *idem*, *l.c.*: 523; *Anthelia domuncula*, Blainville, 1834: 524; *Halispongia suberica*, *idem*, *l.c.*: 532; *Suberites domuncula*, Nardo, 1834: 714; *Spongia suberica*, Lamarck, 1836: 537; *Alcyonium domuncula*, *idem*, *l.c.*: 600; *A. compactum*, *idem*, *l.c.*: 606; *Halichondria suberica*, Bellamy, 1839: 268; Thompson, 1840: 254; *H. suberea*, Johnston, 1842: 139, pl. xii, figs. 5–6; *H. ficus*, *idem*, *l.c.*: 144, pl. xv, figs. 4–5; *H.*

domuncula, Gray, 1848: 13; *H. ficus, idem, l.c.*: 15; *H. suberea*, Bowerbank, 1858: 287, pl. xxiii, fig. 25; *H. ficus, idem, l.c.*: 298, pl. xxiv, fig. 25; *H. compacta*, Lieberkühn, 1859: 520; *Halina suberea*, McAndrew, 1861: 235; *H. ficus, idem, l.c.*: 235; *Hymeniacidon subereum*, Bowerbank, 1862: 1111; *idem, l.c.*: 1129; *Suberites domuncula*, Schmidt, 1862: 67; Crivelli, 1863: 286, pl. iii, figs. 1–5; Kölliker, 1864: 71; *Hymeniacidon ficus*, Bowerbank, 1864: 222; *H. suberea, idem, l.c.*: 231, pl. i, fig. 23; *H. virgultosa, idem*, 1866: 193; *H. suberea, idem, l.c.*: 200; *H. ficus, idem, l.c.*: 206; *H. farinaria, idem, l.c.*: 269; *Halichondria suberea*, Hughes, 1866: 86; *Reniera ficus*, Schmidt, 1866: 16; *Hymeniacidon farinaria, idem, l.c.*: 16; *Reniera virgultosa*, Gray, 1867: 518; *Halichondria farinaria, idem, l.c.*: 519; *Suberites suberea, idem, l.c.*: 523; *Ficulina ficus, idem, l.c.*: 523; *Suberites domuncula*, Marcusen, 1867, p. 358; *S. suberia*, Parfitt, 1868: 12; *Halichondria farinaria*, Bowerbank, 1868: 124; *Suberites domuncula*, Schmidt, 1868: 14; *Hymeniacidon ficus*, Norman, 1869: 297; *H. subereus, idem, l.c.*: 331; *H. ficus, idem, l.c.*: 331; *H. suberea*, Wright, 1870: 225; *Halichondria farinaria, idem, l.c.*: 226; *H. suberea*, Carter, 1870: 82; *Suberites heros*, Schmidt, 1870: 46; *S. lütkenii, idem, l.c.*: 47, pl. v, fig. 7; *S. domuncula, idem, l.c.*: 76; *S. ficus, idem, l.c.*: 76; *Hymeniacidon virgultosa, idem, l.c.*: 76; *H. suberea, idem, l.c.*: 76; *Halichondria farinaria, idem, l.c.*: 77; *Alcyonium domuncula*, Moulins, 1872: 342; *Suberites lütkenii*, Möbius, 1873: 148; Schmidt, 1874: 429; *Hymeniacidon virgultosa*, Bowerbank, 1874: 89, pl. xxxv, figs. 1–5; *H. suberea, idem, l.c.*: 91, pl. xxxvi, figs. 1–4; *H. ficus, idem, l.c.*: 92, pl. xxxvi, figs. 10–17; *Halichondria farinaria, idem, l.c.*: 177, pl. lxx, figs. 5–8; *Hymeniacidon ficus*, M'Intosh, 1874: 143; *Halichondria suberea*, Carter, 1875: 197; *H. ficus, idem, l.c.*: 197; *Suberites domuncula*, Schmidt, 1875: 115; *S. ficus, idem, l.c.*: 116; *S. lütkenii*, Lütken, 1875: 190; *S. domuncula*, Carter, 1878: 157; Krukenberg, 1879: 66, pl. i, figs. 3–4; *idem*, 1879: 705; Czerniawsky, 1880: 236; Krukenberg, 1880: 37; *S. montalbidus*, Carter, 1880: 256; *S. domuncula*, Leslie and Herdman, 1881: 269; Vosmaer, 1881: 4; *Halichondria suberea*, Carter, 1881: 255; *Hymeniacidon virgultosa*, Bowerbank, 1882: 83; *H. subereus, idem, l.c.*: 88; *H. ficus, idem, l.c.*: 89; *Halichondria farinaria, idem, l.c.*: 114; *H. suberia*, Carter, 1882: 353; *H. ficus, idem, l.c.*: 353; *Suberites montalbidus, idem, l.c.*: 353; *S. domuncula*, Graeffe, 1882: 318; Krebs, 1882: 295; Vosmaer, 1882: 20; *S.* sp., *idem, l.c.*: 32, pl. i, figs. 22–23, pl. iv, figs. 140–144; *S. domuncula*, Marion, 1883: 65, 68; Carter, 1883: 30; Vosmaer, 1884: 121; *idem*, 1885: 332; *S. montalbidus*, Fristedt, 1885: 19, pl. iii, fig. 3; *S. ficus, idem, l.c.*: 20; *S. virgultosa, idem, l.c.*: 21; *S. suberia*, Higgin, 1886: 86; *S. lütkenii*, Marenzeller, 1886: 3; *S. domuncula*, Vosmaer, 1886: 457; Thomson, 1887: 241, pl. xvii; Ridley and Dendy, 1887: p. xlv; *S. montalbidus*, Fristedt, 1887: 428; *Alcyonium compactum*, Topsent, 1888: 134; *Suberites domuncula, idem, l.c.*: 134; *S. suberea, idem, l.c.* 150; *S. ficus, idem, l.c.*: 150; *idem*, 1888: 1299; *S. domuncula*, Lendenfeld, 1888: 65; *S. domunculus*, Sollas, 1888: 415; *S. suberea*, Hanitsch, 1889: 158; *S. ficus, idem, l.c.*: 195; *S. ficus, idem, l.c.*: 195; *Halichondria farinaria*, Topsent, 1889: xxxviii; *Suberites domuncula*, Dendy, 1889: 56; Lendenfeld, 1889: 798; Topsent, 1890: 232; Hanitsch, 1890: 195, 214; *S. ficus*, Hanitsch, 1890: 195, 216; *S. suberea*, Topsent, 1890: 202; *S. ficus, idem, l.c.*: 202; *S. farinaria, idem, l.c.*: 203; *S. ficus*, Topsent, 1891: 14; *idem*, 1891: 127, 129; *idem*, 1891: 529; *S. domuncula*, Hanitsch, 1891: 218; *S. ficus*,

idem, l.c.: 219; *S. ficus*, Topsent, 1892: 128; *S. latus*, Lambe, 1893: 71, pl. iii, fig. 7, pl. v, fig. 7; *S. domunculus*, Holt, 1892: 239; *S. ficus*, Levinsen, 1893: 410, fig. 21; *S. farinaria, idem, l.c.*: 412; fig. 22; *S. montalbidus, idem, l.c.*: 413, fig. 23; *S. domuncula*, Celesia, 1893: 1, pls. v–viii; *S. virgultosus*, Hanitsch, 1894: 177; *S. domuncula, idem, l.c.*: 177; *S. ficus, idem, l.c.*: 177; *S. farinarius, idem, l.c.*: 177; *S. ficus*, Topsent, 1894: 21, 23, 26; *Halichondria farinaria, idem, l.c.*: 21, 26; *Suberites domuncula, idem, l.c.*: 23; *S. suberea*, Lambe, 1894: 126, pl. iv, fig. 3; *S. montalbidus, idem, l.c.*: 127, pl. iii, fig. 6; *S. ficus*, Weltner, 1894: 327; *S. heros, idem, l.c.*: 328; *S. domuncula*, Heider, 1895: 283; *S. suberea*, Lambe, 1895: 126, pl. iv, fig. 3; *S. latus, idem, l.c.*: 127; *S. montalbidus, idem, l.c.*: 127, pl. iii, fig. 6; *S. ficus*, Topsent, 1896: 275; *idem*, 1896: 118; Lambe, 1896: 193, pl. ii, fig. 4; *Ficulina ficus*, Lendenfeld, 1897: 94, pls. iii, vi, vii, ix; *Suberites domuncula, idem, l.c.*: 118, pls. iv, vii, xi; Topsent, 1898: 126; *Ficulina ficus, idem, l.c.*: 129; *Suberites domuncula*, Thiele, 1898: 37; *S. heros, idem, l.c.*: 37; *S. lütkenii, idem, l.c.*: 38; *S. subereus, idem, l.c.*: 38, pl. i, figs. 11–12, pl. viii, fig. 7; *S. placenta, idem, l.c.*: 39, pl. viii, fig. 8; *S. sericeus, idem, l.c.*: 39, pl. viii, fig. 10; *Prosuberites inconspicuus, idem, l.c.*: 40, pl. viii, fig. 12; ? *P. exiguus, idem, l.c.*: 40, pl. viii, fig. 13; *Ficulina ficus*, Topsent, 1899: 105; *Ficulina ficus, idem*, 1900: 203, pl. v, figs. 6–15; *Suberites domuncula, idem, l.c.*: 225, pl. vi, figs. 1–9; *S. suberea*, Lambe, 1900: 161; *S. ficus, idem, l.c.*: 161; *S. montalbidus, idem, l.c.*: 162; *idem*, 1900: 24; *idem*, 1900: 277; *S. lütkenii*, Topsent, 1900: 213; *S. domuncula*, Cotte, 1901: 1; *idem*, 1901: 95; Bidder, 1902: 380; *Ficulina ficus*, Rousseau, 1902: 18, fig. 11; *Suberella heros*, Thiele, 1905: 415; *Suberites domuncula, idem, l.c.*: 416; Swartschewsky, 1905: 35, pl. ii, fig. 5, pl. iv, fig. 11, pl. vi, fig. 4; *S. heros, idem, l.c.*: 35; *S. montalbidus, idem*, 1906: 318, pl. xiii, fig. 3; *Ficulina ficus*, Lundbeck, 1907: 559; *idem*, 1909: 453; *Suberites* sp., Arndt, 1912: 114; *Ficulina ficus*, Stephens, 1912: 21; Massey, 1912 (see index p. 224 for page reference); Müller, 1913: 291; Topsent, 1913: 25; *F. lütkenii, idem, l.c.*: 25; Stephens, 1915: 35; *Suberites domuncula*, Babić, 1921: 14; *idem*, 1922: 272; *Ficulina ficus*, Ferrer, 1922: 269; *Suberites domuncula*, Topsent, 1925: 633; Dembowska, 1926: 163; *Ficulina ficus*, Broch, 1927: 5; *Suberites domuncula*, Topsent, 1928: 154; *Ficulina ficus, idem, l.c.*: 156; Arndt, 1928: 33, figs. 33, 34; Hentschel, 1929: 928; *Suberites lütkenii*, Hentschel, 1929: 928; *S. domuncula*, Burton, 1932: 201; Vosmaer, 1933: 426, pl. i, figs. 2, 4, 12, 16, pl. ii, figs. 10–11, pl. iv, figs. 2, 10, pl. xviii, figs. 6–14, pl. xx, figs. 11–13, pl. xxxvii, figs. 5–10; Burton, 1934: 313; *Ficulina ficus, idem, l.c.*: 313; *Suberites lütkenii, idem*, 1934: 14; *S. domuncula*, Topsent, 1934: 14; *Ficulina ficus, idem, l.c.*: 16; *Suberites domuncula*, Arndt, 1935: 39; *Ficulina ficus, idem, l.c.*: 39; *Suberites domuncula*, Burton, 1935: 77; *Choanites ficus*, de Laubenfels, 1949: 19; *Suberites domunculus*, de Laubenfels, 1949: 20, figs. 16–18.

Description of Species: Encrusting in young stages, later may assume one of two forms, either massive or globular, rarely lobate, and growing round an empty gastropod shell containing a hermit crab, or massive, globular, ficiform, clavate, or irregularly lobate; surface even, finely hispid or harsh to touch; texture firm; oscules few, large, apical; colour, alive, white, greyish-white, white and red with blue patches, white marbled with blue and red, and various shades of yellow, orange, and red;

skeleton a dense, irregular reticulation of tylostyli, 0·09 to 0·45 by 0·008 mm., with microstrongyla or microxea for microscleres, smooth or microspined, often sparingly present, 0·015 to 0·05 mm. long.

DISTRIBUTION: Throughout the Arctic Ocean, in the Atlantic Ocean north of 0° latitude, and in the Pacific Ocean north of approximately 35° latitude. Bathymetric range from low-water springs to 1,331 m. (the optimum probably 0 and 90 m.).

ECOLOGY: Almost any kind of habitat, but more particularly on sandy or muddy bottom (presumably where gastropods or shells are likely to be present).

APPENDIX

THE ECOLOGY OF *SUBERITES DOMUNCULA*

Although *Suberites domuncula*, as now understood, has received so much attention in the literature, the data on bathymetric range and ecology are singularly meagre. This is true even where, as has happened several times, an author is reporting on a collection containing hundreds of specimens. There is, however, a series of observations, given by Massy (1912), but as these are scattered over 215 pages and obscured by a wealth of faunistic data relating to other marine organisms, it has been thought worth while to abstract these and publish them in tabular form as an appendix.

The identifications given in Massy (*l.c.*) were by Miss Jane Stephens, and one of the more interesting points to emerge is that in this series of trawlings off the coast of Ireland, comprising over 500 stations, sponges were obtained at more than 100 stations, and the vast majority of these belonged to *Suberites domuncula*. Only a half-dozen other species were represented in the hauls, with a total of a dozen or more specimens. This substantiates the impression left by a study of the literature, as well as by personal experience, that the species is widespread over the continental shelf throughout its range and its population figures are comparatively high. It is, however, unfortunate that Massy should have been so indefinite on this last point. In describing 'number of specimens taken' the words 'few', 'several', 'moderate', 'many' are far too indefinite. Had actual numbers been included, the list would have been so much more valuable.

Summary of catches of Suberites domuncula *recorded by Anne L. Massy off the coast of Ireland*

Page	*Station*	*Number of specimens taken*	*Depth in fathoms*	*Nature of bottom*	*Commensals*
3	12	1	12–14	sand and shells	*Eupagurus* sp.
15	43	few	17–23	fine sand	*E. cuanensis* ?
16	44	moderate	25–27	sand	,,
17	45	,,	40–60	,,	—
21	57	1	48–60	fine sand	*E. cuanensis*
26	70	several	25–26	fine sand and mud	—
28	77	2	27–30	sand and mud	*E.* sp.
29	80	few	12–17	mud and sand	—
31	83	moderate	$14\frac{3}{4}$–$15\frac{1}{2}$	sand and shells	—
35	102	few	12–16	—	*E.* sp.

Page	*Station*	*Number of specimens taken*	*Depth in fathoms*	*Nature of bottom*	*Commensals*
35	104	1	14–16	—	*E.* sp.
36	107	few (10+)	20–23	—	*E.* sp.
37	108	few	13–14	—	*E.* sp.
38	113	8	21	—	*E.* sp.
38	114	19	21–25	—	2 with *E. bernhardus*; 17 on *Dentalium*
39	116	1	16	—	*E.* sp.
40	118	1	21–23	mud and sand	*E.* sp.
41	122	2	11–13	—	*E.* sp.
42	126	12	43–60	—	10 with *E.* sp.; 2 on *Dentalium*
42	125	1	12–14	—	*E.* sp.
43	129	few	13–15	—	*E.* sp.
44	131	6	21–28	—	*Dentalium*
45	135	12+	9–10	—	,,
46	139	2	14–16	—	,,
47	143	3	17–20	—	*E.* sp.
49	146 *bis*	1	$13\frac{1}{2}$–16	—	*E.* sp.
53	165	1	19–20	sand and gravel	*E.* sp.
55	173	3	13–16	—	*E.* sp.
62	198	2	48	—	*E.* sp.
62	199	many	18–24	—	*E. bernhardus Aequipecten*
64	203	2	—	—	*E. bernhardus*
66	206	1	11	—	—
69	216	2	12–19	—	*E.* sp.
69	217	3	32–50	—	*E.* sp.
71	222	1	15–$16\frac{1}{2}$	—	*E. cuanensis*
72	224	few	44	sand	1 with *E. cuanensis*
80	248	2	10–12	—	,, ,,
83	253	3	13	—	—
85	258	1	21–23	mud	—
86	261	very scarce	28	fine sand and shells	—
87	262	1	35–43	sand	—
88	264	4	17–23	—	—
88	265	few	$24\frac{1}{2}$–25	sand and shells	*E. bernhardus*
93	280	1	8	sand	—
96	287	6	22	fine sand and shells	*E. cuanensis*
96	288	9	$12\frac{1}{2}$–$13\frac{1}{2}$	,,	—
97	289	2	22–23	mud and sand	—
97	292	2	19–22	sand and shells	*E. cuanensis*?
104	313	1	—	—	—
106	318	1	13	coarse sand, gravel	—
107	322	moderate	23	sand	*E. cuanensis*
107	323	,,	$21\frac{1}{2}$–$23\frac{1}{2}$	fine sand	*E. cuanensis* and *E. bernhardus*
109	328	2	$10\frac{3}{4}$	fine sand, shells	—
112	336	3	$14\frac{1}{2}$–17	fine sand	*E. bernhardus*
119	357	1	—	—	—
124	374	1	24–25	sand	—
124	375	1	$23\frac{1}{2}$–24	fine sand	—
136	414	2	$16\frac{3}{4}$–$19\frac{1}{4}$	,,	—
138	418	4	23–$23\frac{1}{2}$	fine sand, shells	*E. cuanensis*
142	438	1	8–$8\frac{1}{2}$	,,	—
143	439	few	$19\frac{1}{2}$–$23\frac{1}{2}$	mud and sand	*E. bernhardus*
144	443	1	13–19	sand	,,
145	444	8	$22\frac{1}{2}$–24	fine sand, shells	*E.* sp.
145	445	many	25–26	sand	—
146	447	2	5–6	,,	—
147	451	2	40–66	mud, sand, shells	*E. bernhardus*

Page	*Station*	*Number of specimens taken*	*Depth in fathoms*	*Nature of bottom*	*Commensals*
149	455	1	14–15½	fine sand, shells	—
153	465	1	10	fine sand	—
157	476	few	23	sand and shells	*E.* sp.
157	477	1	24–25	fine sand	*E.* sp.
161	484	1	14–21½	fine sand, shells	*E. bernhardus*
163	487	1	19–23	fine sand, mud	—
164	491	1	7½–9	fine sand	—
168	500	1	10–11½	,,	—
168	501	1	35–37	mud	—
169	504	few	42–46½	mud and sand	—
171	507	1	13–14¾	fine sand, shells	—
173	513	1	23½–25	,,	—
173	514	several	22–24	sand	*E. bernhardus*
174	515	1	22–26	fine sand, shells	—
174	516	1	19–22	sand and shells	—
178	526	2	7–7½	sand	—
178	527	1	10–13½	,,	—
180	532	1	14–14¾	fine sand	on shell
181	535	2	21–22½	sand and shells	*E.* sp.
186	545	2	16½–18½	mud	—
189	553	2	41–52	sand and shells	*E. bernhardus*
190	554	2	14–19	,,	—

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NOTES ON ASTEROIDS IN THE BRITISH MUSEUM (NATURAL HISTORY)

III.[1] *LUIDIA*

By AILSA M^cGOWN CLARK

(*With Plates* 39–46)

THE following species of the genus *Luidia* are represented in the Museum collection; those of which the types are held are marked with an asterisk and those commented on in the text, with a dagger:

aciculata Mortensen
*†*africana* Sladen
alternata (Say), with subspecies †*numidica* Koehler
*†*aspera* Sladen
atlantidea Madsen († under *africana*)
avicularia Fisher
bellonae Lütken
ciliaris (Philippi)
clathrata (Say)
*†*columbia* (Gray)
elegans Perrier († under *africana*)
foliolata Grube
*†*hardwickii* (Gray) (incl. **forficifer* Sladen)
**heterozona* Fisher
**longispina* Sladen
maculata Müller & Troschel, with forma †*herdmani* forma n.
magnifica Fisher (†under *aspera*)
mauritiensis Koehler
neozelanica Mortensen
penangensis de Loriol
phragma H. L. Clark
prionota Fisher
†*quinaria* von Martens (incl. **limbata* Sladen)
sarsi Düben & Koren († under *africana*)
†*savignyi* (Audouin)
*†*scotti* Bell.
senegalensis (Lamarck)
tessellata Lütken († under *columbia*)

Sladen's very full descriptions of the 'Challenger' material are excellent in themselves, but examination of the type specimen of *Petalaster hardwickii* Gray shows that *L. forficifer* Sladen is a synonym of this. Gray's description was, as usual, very brief and inadequate in the light of the many species since described. His type specimen is accordingly dealt with in detail here, as are the types of Bell's species *Luidia scotti* from off Rio de Janiero. *L. doello-juradoi* Bernasconi (1941) seems to be identical with the latter. Sladen's types of *Luidia aspera* were found to include specimens of two other species, so that only the one described by him is left as the holotype.

The very fine 'Siboga' report on *Luidia* by Döderlein (1920) provides a valuable subdivision of the genus and a comprehensive survey of the species known up to that time. The following species (see p. 380) have been described since 1920 or were not included by Döderlein.

Döderlein's four main groups are most convenient for splitting up this unwieldy genus into more manageable units, but the limits between them are not absolutely sharp. For instance, *L. scotti* Bell bridges the gap between the *Clathrata* and *Alternata* groups. Also the subgenus *Integraster* with such species as *L. avicularia* Fisher and

[1] Notes I and II appeared in *Novit. Zool.* **42** (1948) and *Bull. Brit. Mus.* (*Nat. Hist.*) *Zool.* **1** (4) (1950) respectively.

Name	*Locality*	*Group*
moroisoana Goto, 1914: 301	Japan	*Quinaria*
yesoensis Goto, 1914: 306	,,	,,
superba A. H. Clark, 1917: 171	Pacific coast of Colombia	*Alternata* (?)
porteri A. H. Clark, 1917*a*: 153	Chile	*Ciliaris* (?)
scotti Bell, 1917: 8	Off southern Brazil	*Clathrata*
neo-zelanica Mortensen, 1925: 278	New Zealand	*Ciliaris*
varia Mortensen, 1925: 275	,,	*Alternata*
aciculata Mortensen, 1933: 425	St. Helena	*Ciliaris*
hexactis H. L. Clark, 1938: 73	NW. Australia	*Quinaria*
heterozona Fisher, 1940: 265	W. Africa	,,
mortenseni Cadenat, 1941: 53 (= *heterozona*)	,,	,,
doello-juradoi Bernasconi, 1941: 117 (= *scotti*)	Argentina	*Clathrata*
patriae Bernasconi, 1941: 117	,,	,,
quequenensis Bernasconi, 1942: 253	,,	*Alternata*
bernasconiae A. H. Clark, 1945: 19 (= *alternata*)	NW. Atlantic	,,
atlantidea Madsen, 1950: 192	W. and NW. Africa	*Ciliaris*

L. heterozona Fisher joins up the *Quinaria* and *Ciliaris* groups. Indeed, Fisher (1940: 265) puts the last-named species actually in the *Ciliaris* group and Döderlein himself in his 'family tree' of the genus (p. 223) illustrates the link up of the two groups through the subgenus *Integraster*.

As Mortensen (1925: 281) says, in discussing *L. neozelanica*, most of the species belonging to the *Ciliaris* group are distinguished by apparently trivial characters, coupled with their geographical location. This certainly applies to the three species *L. sarsi* from western Europe, *L. atlantidea* from West and North-West Africa, and *L. africana* from South Africa, in which the differing form and location of the pedicellariae and the size of the paxillar spinelets provide the main characters by which they can be recognized.

However, it seems to me that too much importance has sometimes been placed on the occurrence or non-occurrence of pedicellariae as a specific character, rather than on their shape. For instance, *Luidia sibogae* Döderlein (p. 262) is based on a single juvenile specimen with R = only 19 mm., so it is not surprising that pedicellariae are only found in the interbrachial angles. The only other character in which it seems to differ from typical *L. savignyi* (Audouin) is in having unusually large spine-bearing paxillae, itself a somewhat variable feature in the latter species. Döderlein himself suggests that it may only be a young specimen of *L. savignyi*. Similarly I am doubtful of the specific value of *L. mascarena* Döderlein (1920:261) as distinct from *L. savignyi* also. The few specimens known from Mauritius and South-East Africa seem to have few, if any, ventro-lateral pedicellariae, but this is, in my opinion, at most a subspecific distinction and anyway may not be borne out by a good series of adult specimens.

At one time *Luidia ciliaris* (Philippi) was thought to have an Atlantic variety which was called *normani*, distinguished from the typical Mediterranean form by the possession of trivalved rather than bivalved ventral pedicellariae. However, even Ludwig, the initiator of this variety, abandoned it on the evidence of further material, as, I suspect will also be the case with some of the other forms of *Luidia*.

In the text that follows the reference lists quoted are not necessarily complete.

CLATHRATA GROUP

Luidia columbia (Gray)

TEXT-FIGS. 1 and 2, PL. 39, FIG. 1

Petalaster columbia Gray, 1840: 183.
non *Luidia columbia*, H. L. Clark, 1910: 331, pl. 1, fig. 2; Döderlein, 1920: 253; Bernasconi, 1943: 7, pl. 4, figs. 2 and 3 (= *L. tessellata* Lütken).
Luidia brevispina Lütken, 1871: 288; Döderlein, 1920: 253, figs. 10, 14, and 22.

Type: R/r = 58–65 mm./12 mm. = 5/1. San Blas. Cuming collection.

The specimen is dry and not in a very good condition. The ventral side seems to have been coated in glue particularly at the interbrachial angles which are distorted. Most of the spines, short as they are, have become adpressed to the surface or broken off.

NOTE: Gray has obviously assumed that the specimen came from the San Blas on the Atlantic side of the isthmus of Panama, which was at that time part of Colombia, hence his specific name. I am unable to trace any place called San Blas on the Pacific coast of Colombia, but there is a town of that name on the west coast of Mexico near Mazatlan, where other similar specimens have been taken (the types of *L. brevispina* Lütken). Since Cuming only collected on the *west* coast of Central America and some shells from his collection are recorded as coming from 'San Blas, Gulf of California' it is presumably from there that this specimen came.

DIAGNOSIS. A species of *Luidia* belonging to the *Clathrata* group of Döderlein, with two rows of lateral paxillae forming transverse rows with the larger supero-marginal series; dorsal paxillae with large, flat, polygonal, central granules surrounded by much more slender peripheral spinelets; no pedicellariae; one very short, tapering marginal spine just below the ambitus on each infero-marginal plate, with two shorter flattened ones above it; ventral infero-marginal spines very short and squamiform; the single ventro-lateral plates hardly projecting from underneath the inner ends of the corresponding infero-marginals; three relatively short, thick adambulacral spines.

DESCRIPTION. The largest dorsal paxillae are the supero-marginals which are proximally wider than long but distally become square. They form transverse series with the two outermost lateral rows of paxillae, which are square (or slightly wider than long) proximally, becoming relatively longer distally. Towards the middle of the rays the paxillae become smaller and more irregularly arranged, having about seven flat, polygonal, central granules as compared with the twelve or so of the supero-marginal series. The peripheral spinelets around the paxillae are much more slender.

There are no pedicellariae on either side.

The infero-marginal plates are, as usual, very short and raised into a ridge extending a little way on to the dorsal side, where they bear a few short stumpy spinelets. On the ambitus, or just above it, are two (rarely one), short, flattened spines, expanded outwardly rather like a hoof seen in side view. Below these comes a single short tapering spine, about half as long again as the two above it but, even so, not as much as 1 mm. in length. On the ventral side there are two somewhat irregular rows of expanded, squamiform spinelets, with smaller peripheral ones on either side.

The ventro-lateral plates are largely overlain by the infero-marginals so that only a small lobe protrudes. It is impossible to tell how many there are in the inter-brachial angle owing to the poor condition of the specimen. They do not appear to bear any distinct armature, although possibly they may carry a squamiform spinelet similar to and consecutive with the infero-marginal spinelets.

The adambulacral plates have the usual curved, compressed furrow spine followed by two other spines, the middle one being slightly curved at the base, otherwise

FIG. 1.

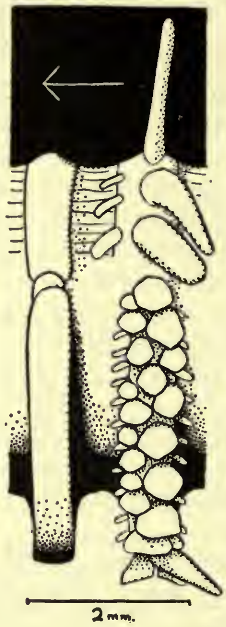


FIG. 2.

TEXT-FIG. 1. *Luidia columbia* (Gray). Type. Dorsal view of two infero-marginal plates and the adjacent paxillae from the proximal part of an arm.

TEXT-FIG. 2. *Luidia columbia* (Gray). Type. Ventral view of one side of two segments, that on the left having been treated with sodium hypochlorite. (The arrow points towards the mouth.)

cylindrical and gently tapering, while the outer one is stouter and a little shorter. There may be several spinelets along the adoral edge of each adambulacral plate, of which one on a level with the outermost large spine may be enlarged occasionally.

There is a faint tinge of greenish colour on the dorsal side.

REMARKS. Lütken, H. L. Clark, and Döderlein have all had a mistaken impression of this species, which is hardly surprising after Gray's very brief diagnosis, for Lütken when describing *L. tessellata* (1859: 40) from Puntarenas (on the west coast of Costa Rica) queried it as a possible synonym of *Luidia columbia*, which it is not, and later (1871: 288) described as a separate species *L. brevispina* from Mazatlan, Mexico, which *is* clearly identical with *L. columbia*.

There are two specimens in the British Museum identified as *Luidia tessellata* by Lütken and labelled as coming from Realejo, Puntarenas (the type locality). These fully agree with the description Döderlein has given for *Luidia columbia* (p. 253), having long slender marginal and adambulacral spines. The longer of the two ambital spines (the lower one) is 3·5–4 mm. in length, while the upper one is usually about 2 mm. long. The adambulacral spines are about 3 mm. long and with the slender spines on the ventral surface of the infero-marginal plates give the under side a 'shaggy' appearance quite distinct from that of *Luidia columbia* with its very abbreviated armature.

Luidia tessellata is then a valid species and it is *L. brevispina* which is the synonym of *Luidia columbia* (Gray).

As for *Luidia marginata* Koehler (1911*a*: 17) from Mazatlan, Döderlein (p. 251) says that it differs from *L. brevispina* (i.e. *columbia*) in having numerous interradial ventro-lateral plates in the interbrachial angles, although Koehler himself makes no mention of this. It is unfortunate that the type of *L. columbia* is in such a condition in this region that no comparison can be made.

ALTERNATA GROUP

Luidia scotti Bell

TEXT-FIG. 3; PL. 40, FIG. 1

Luidia scotti Bell, 1917: 8.
Luidia doello-juradoi Bernasconi, 1941: 117; 1943: 8, pl. 1, fig. 3, pl. 2, figs. 2–3, pl. 3, figs. 4–5.

St. 42. 'Terra Nova' Expedition. 22° 56′ S.: 41° 34′ W. (off Rio de Janeiro). 73 m. 15 specimens.

Holotype selected by A. M. Clark with R = 60 mm., r = 8 mm., R/r = 7·5/1, br. = 9 mm., British Museum registered number 1915.2.1.64.

DIAGNOSIS. A species of *Luidia* linking the *Alternata* and *Clathrata* groups, with two lateral rows of paxillae forming transverse rows with the supero-marginal series; no dorsal pedicellariae but three- or four-valved ones are present on most of the ventro-lateral plates in the interbrachial angles and at the bases of the arms; one large marginal spine at the ambitus with a smaller one above it and four or five others below on the ventral face of the plate, all of them much smaller than the ambital spine; four adambulacral spines, the outermost two placed on a line parallel to the furrow.

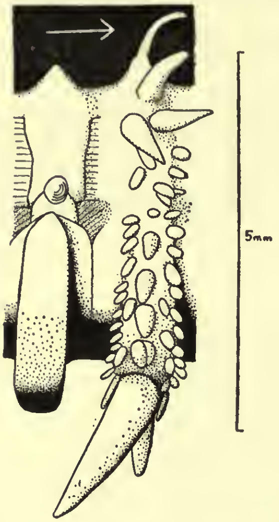
DESCRIPTION. The sides of the rays are almost vertical up to the second row of paxillae in from the supero-marginal series. The centre of the disk and rays is quite flat. The madreporite is concealed.

The supero-marginal paxillae are square or slightly longer than wide. Forming transverse rows with them are two series of lateral paxillae, of which the outer row, at least, are wider than the supero-marginals. Across the middle of the ray there are about thirteen rows of less regularly arranged plates, which become progressively smaller towards the mid-radial line. The small central plates, both of the disk and the arms, bear three or four short, thick, spaced paxillar spinelets surrounded by about twelve thinner peripheral ones. The number of spinelets on each paxilla increases

towards the sides of the rays to the outermost lateral series, each plate of which bears about twelve central and thirty peripheral spinelets. All the paxillar spinelets have the rounded tops distinctly thorny under magnification.

There are no dorsal pedicellariae.

The infero-marginal plates are mainly ventral in position but have a small area covered with paxillar spinelets on their uppermost edge at the side of the arm. Below this, at the ambitus of the ray, is a large, pointed, curved spine about 2·5 mm. in length. Above this is a smaller spine, usually about 1 mm. long, although rarely it is two-thirds as long as the ambital spine. On the ventral side of each infero-marginal plate is a series of four or five much smaller pointed spines, slightly flattened, one being occasionally replaced by a pedicellaria as in the figure. The outermost is the largest and measures just over 1 mm. in length. On each side of this row there may be a series of smaller, stumpy spines, while on the edges of the plates are the usual fringing spinelets.



TEXT-FIG. 3. *Luidia scotti* Bell. Type. Ventral view of one side of two arm segments, that on the left having been treated with sodium hypochlorite. (The arrow points towards the mouth.)

The adambulacral plates have a curved, sabre-like furrow spine backed by a larger tapering one, followed in turn by a pair of spines of which either the adoral may be smaller while the other is the same size as the second spine, or else both of them are smaller. On the outer edge of the plate lie one or two smaller spines or spinelets. In the interbrachial angle each ventro-lateral plate bears a three- or four-valved pedicellaria, but these only extend on to the proximal part of the ray up to about the sixth joint, beyond which there are only spinelets. There are no pedicellariae on the mouth plates.

The colour has been lost in the type after thirty-five years in spirit, but some other specimens are dark brown along the middle of the rays while a small one has brown blotches at intervals across the arms, as Bell described when the material was fresh.

VARIABILITY. A paratype slightly larger than the specimen described above has the ventro-lateral pedicellariae extending on to most of the plates in the proximal half of the arm, not just on those in the interbrachial angle.

The long narrow arms with an R/r ratio of 7 (or more)/1 are found in all the specimens from this station.

REMARKS. Bell compared this species with *Luidia clathrata* (Say), but the relatively smaller supero-marginal paxillae compared to the outermost lateral series and the presence of pedicellariae and blotched coloration readily distinguish his own species. These characters are more typical of the *Alternata* group of Döderlein than of the *Clathrata* group.

The affinities of *Luidia scotti* are obviously with the species included in Döderlein's subgenus *Armaster*, particularly *L. armata* Ludwig (1905: 85) and *L. ludwigi* Fisher

(1906*a* and 1911). However, without Pacific material for comparison it cannot be decided whether the forms on both sides of South and Central America represent the same species. They are certainly very closely related.

Luidia scotti is obviously identical with *L. doello-juradoi* Bernasconi (1941) from the mouth of the river Plate. The type of that species also has supero-marginal paxillae equal in length to, but not so wide as, the outermost lateral row and three- or four-valved pedicellariae on the ventro-lateral plates. The only difference appears to be that the two marginal spines are almost equal in length in *L. doello-juradoi*, whereas in the types of *L. scotti* the upper one is usually less than half the size of the lower.

It is unfortunate that Bell's description was so brief and omitted any mention of the distinctive pedicellariae.

Luidia savignyi (Audouin)

PL. 40, FIG. 2

Asterias savignyi Audouin, 1826.
Luidia savignyi, Gray, 1840: 183; Perrier, 1875: 342; Koehler, 1910: 10, pl. 1, fig. 5, pl. 6, fig. 3.
Luidia mascarena Döderlein, 1920: 261, fig. 5.

Number	*B.M. Reg. No.*	*Locality*	*Source*
1	1903.4.2.39	Wasin, N. of Zanzibar, 10 fms.	Crossland collection
1	1904.3.3.66	Pearl Bank, Ceylon	Herdman collection
2	69.6.25.9–10	Gulf of Suez	R. McAndrew
1	1951.1.6.1	28° 32′ S.: 32° 26′ E., NE. of Durban, 20 m.	Cape Town University
1	1927.1.10.90	Suez	C.U. Suez Canal Expedition

REMARKS. *Luidia mascarena* Döderlein, from Mauritius, apparently only differs from *L. savignyi* in lacking ventro-lateral pedicellariae. This is the case with Döderlein's two specimens and with de Loriol's one, according to Koehler. The specimen from north-east of Durban, with R = 140 mm., has a single pedicellaria on each side of each interbrachial angle, usually on the third or fourth plate, and three or four others farther out on the arm. The Wasin specimen is unfortunately juvenile with R = only 35 mm. It has a total of three ventral pedicellariae, of which two are in one interbrachial angle. The Suez specimen collected by the Cambridge University Expedition (R = 38 mm.) has no ventral pedicellariae at all, as remarked on by Mortensen (1926: 121), although the other two from the same locality, collected by McAndrew, both have pedicellariae on most of the ventro-lateral plates. They are, however, much larger (R = 95 mm. or more).

The specimen from Pearl Bank, Gulf of Manaar (Pl. 40), is that 'with spines on the surface of its rays', this comment of Bell's being reproduced under *Luidia hardwicki* in Herdman's report (1904: 143). The dorsal spines certainly are numerous and very large, measuring about 4 mm. in length. R = 50 mm. Coupled with the powerful dorsal armature, the ventral spines and pedicellariae are unusually long for the species. But for the degree of development of the spines there seems to be little difference between this form and typical *L. savignyi*. More material is needed to show whether it comes within the range of variation of the latter.

The dark patches on the arms of this species when seen through a lens are shown to

be produced by pigmentation on the surfaces of those paxillae which come within the tinted area, extending on to the bases of the paxillar spinelets. This throws into sharp contrast the white tips of the spinelets. In the smaller specimens there is often only a single central spinelet on the mid-radial paxillae.

All of these specimens are seven-rayed in marked contrast to the two five-rayed ones from Madagascar remarked on by Koehler (1910: 14) in his own collection. He says 'les pédicellaires sont particulièrement abondants', which does not seem to be the case in the few seven-rayed specimens of *L. savignyi* known from Mauritius on one side and the coast of South-East Africa on the other. Koehler could not find any other character by which to separate this five-rayed form from the more widespread seven-rayed one.

The very large nine-rayed specimen from Mauritius recorded by Bell (1889: 422) and purchased from M. de Robillard is not *L. savignyi* but *L. mauritiensis* Koehler (1910: 15, pl. 1, figs. 6–7), a species more nearly related to *L. magnifica* Fisher, from the Hawaiian Islands with ten arms and *L. aspera* Sladen from the Philippines, with eight, also having dorsal spines on many consecutive plates. A second specimen actually had ten rays originally, but all have been broken off and nine pieces splinted on to the disk neglecting to leave a gap, so that from the dorsal side nine appears to be the actual number. It is dried and altogether in a bad state.

Luidia aspera Sladen

TEXT-FIGS. 4 and 6

Luidia aspera Sladen, 1889: 248, pl. 43, figs. 1–2, pl. 45, figs. 9–10.

Of the original four types of this species, the two young ten-rayed specimens, each with R = about 40 mm., and a slightly longer odd arm, are obviously not the same as the two large ones from Zamboangan, in the Philippines, in 10 fathoms, as for one thing they do not have blotched coloration. These two small specimens, from 'Challenger' stations 204, off Tablas Island, Philippines, in 100 fathoms, and 209, north of the Admiralty Islands in 150 fathoms, are *Luidia avicularia* Fisher, a species belonging to the *Quinaria* group.

The remaining two specimens, one with eight, the other with ten rays, are otherwise superficially similar, having blotched coloration and several rows of lateral paxillae with erect spines on many consecutive plates. However, closer examination shows that they differ in a number of ways.

Both of them have R = *c.* 170 mm., but in the ten-rayed specimen the disk diameter is 45 mm. and in the eight-rayed one only 35 mm. The latter has much longer and more slender three-bladed pedicellariae, numbering at the most two to each segment, whereas in the ten-armed one there are three ventrolateral plates and correspondingly three pedicellariae (at least proximally), which are also shorter and more abruptly tapering. This is obviously a specimen of *Luidia magnifica* Fisher (1906: 1033), the type of which, also ten-rayed, came from the Hawaiian Islands in 43–73 fathoms. The eight-rayed specimen, which Sladen described and figured, is thus left as the only type of *Luidia aspera*.

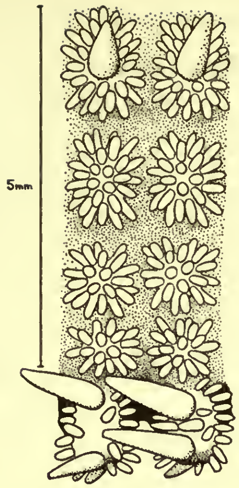


FIG. 4.

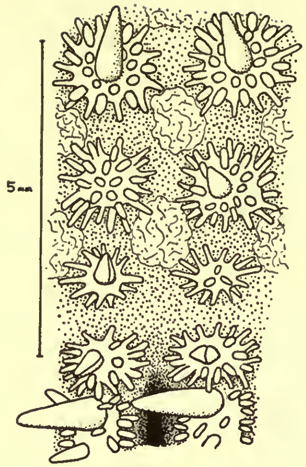


FIG. 5.

TEXT-FIG. 4. *Luidia aspera* Sladen. Type. Dorsal view of the upper ends of two infero-marginal plates and the adjacent paxillae.

TEXT-FIG. 5. *Luidia magnifica* Fisher. Dorsal view of the upper ends of two infero-marginal plates with the adjacent paxillae, showing the papulae between the plates.

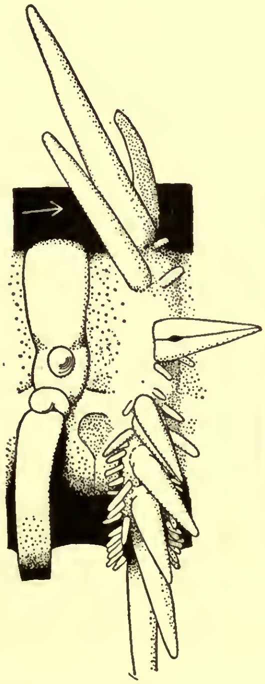


FIG. 6.

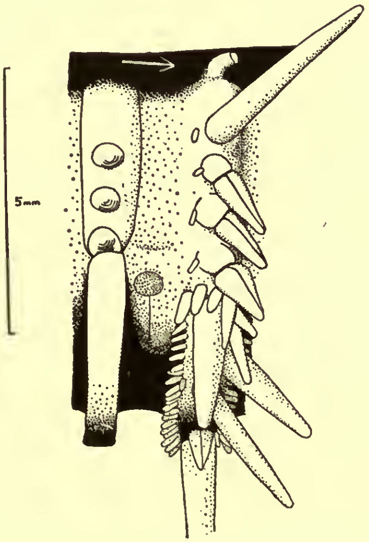


FIG. 7.

TEXT-FIG. 6. *Luidia aspera* Sladen. Type. Ventral view of one side of two segments, that on the left having been treated with sodium hypochlorite. (The arrow points towards the mouth.)

TEXT-FIG. 7. *Luidia magnifica* Fisher. Ventral view of one side of two segments, that on the left having been treated with sodium hypochlorite. (The arrow points towards the mouth.)

The differences between the two species can be listed as follows:

L. aspera	*L. magnifica*
1. Eight rays.	1. Ten rays.
2. Dorsal spines present on the paxillae of the third to the fifth (sixth) lateral rows, counting in from the supero-marginal series.	2. Dorsal spines present on the paxillae of the second to fourth (fifth) lateral rows, counting in from the supero-marginal series.
3. No pedicellariae on the supero-marginal plates.	3. Pedicellariae present on the supero-marginal and some of the first lateral series of paxillae.
4. Ventral pedicellariae about three times as long as their basal width.	4. Ventral pedicellariae only twice as long as their basal width.
5. Two ventro-lateral plates occur on each side of each segment.	5. Three ventro-lateral plates present on each side of each segment.
6. Three large adambulacral spines.	6. Two large adambulacral spines.
7. Furrow spine long.	7. Furrow spine rather short.

The accompanying comparative illustrations (Text-figs. 4–7) of these two specimens help to emphasize these differences.

The occurrence of these two species together suggests that the eight-rayed *Luidia hystrix* Fisher (1906: 1032), also from the Hawaiian Islands in depths of 14–52 fathoms, is probably identical with *L. aspera*. The differences mentioned by Fisher are that in *L. aspera* only three rows of lateral paxillae are spiniferous and there are only three adambulacral spines but two pedicellariae on many segments, whereas in *L. hystrix* nearly all the dorsal paxillae are spiniferous, there are four adambulacral spines, and pedicellariae only occur on about half the segments and then never more than one at a time. I believe these three differences are all subject to variation, but to what extent can only be settled by further material.

The minor differences between the 'Challenger' specimen of *L. magnifica* and the type of that species, which has R = 330 mm., are all in my opinion attributable to the great size of the latter.

The seven-rayed specimen from Mozambique, recorded as *Luidia aspera* by Simpson and Brown (1910: 49) clearly belongs to *L. savignyi* (Audouin), as noted by Fisher (1919: 171).

Luidia aspera is certainly very closely related to *L. savignyi*, and apart from having eight rays rather than seven, the only notable difference seems to be that *L. aspera* has relatively small dorsal spines occurring on many consecutive lateral paxillae, whereas in *L. savignyi* the spines are rather more robust and usually only occur sporadically on the lateral series of paxillae.

Luidia alternata numidica Koehler

PL. 41, FIG. 1

Luidia numidica Koehler, 1911: 3, pl. 1, figs. 8–11.
Luidia alternata var. *numidica* Madsen, 1950: 206, text-fig. 9.

There are five specimens of this subspecies in the Museum collections, of which one from Boa Vista Island in the Cape Verde group, collected by Crossland, has particularly numerous spine-bearing paxillae in the second and third (rarely in the fourth)

rows inwards from the supero-marginals. On the other paxillae the peripheral spinelets are distinctly more slender than the shorter central ones, as in typical West Atlantic *L. alternata*, not like the type of *numidica*. Indeed, this specimen is very near typical *Luidia alternata*.

Luidia maculata forma ***herdmani*** forma n.

TEXT-FIG. 8; PL. 41, FIGS. 2 and 3

Pearl Bank, Gulf of Manaar, Ceylon. Herdman collection. 1904.3.3.8–9. 3 specimens (2 very young).

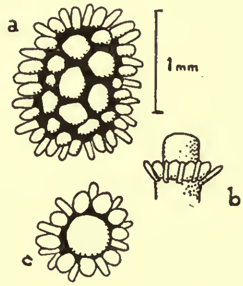
Tuticorin, Madras. Thurston collection. 88.1.2.64. 1 specimen.

Type: larger specimen from Pearl Bank. R/r = 46 mm./8·5 mm. = 5·4/1.

One arm has been broken and has partly regenerated.

DIAGNOSIS. A form of *Luidia maculata* differing from the typical form in having only six arms and the paxillae of the disk and proximal parts of the rays with a knob-like enlarged central spinelet about twice the height of the peripheral ones.

DESCRIPTION. The dorsal side is convex and only the centre of the disk is at all flattened. The madreporite is not visible. The dorsal paxillae of the outermost lateral row are the largest, being even larger than the supero-marginal series. Whereas the latter are square, the lateral paxillae are wider than long. Proximally four lateral series also form regular transverse rows with the supero-marginals, but midradially there are two rows of more numerous, smaller plates. Four to seven somewhat polygonal, thick, granule-like central spinelets and about 14 thinner peripheral spinelets cover each small paxilla of the centre of the arm but on the outermost lateral series there are about 12 central and 28 peripheral spinelets. On the disk also the paxillae are smaller than those on the sides of the rays as well as being round rather than rectangular. They have 1–3 (most commonly 1) very enlarged, round-topped central spinelets surrounded by about 6 less robust ones with the still more slender peripheral spinelets alternating in position with these. The central spinelet usually projects somewhat above the top of the other spinelets. Such paxillae only occur on the disk and at the bases of the arms and their round-topped central spinelets are never comparable to the paxillar spines of such species as *Luidia savignyi* (Audouin).



TEXT-FIG. 8. *Luidia maculata* var. *herdmani* var. n. (*a*) Paxilla of the outermost lateral series, (*b*) lateral, and (*c*) dorsal views of a disk paxilla.

The infero-marginal plates lie almost entirely on the ventral side. Their longest spine is near the upper edge of the plate and reaches a maximum of 2·5 mm. in length. Proximally there may be a smaller spine dorsal to this one, contributing to the fringe of spines projecting laterally from the ambitus of the ray. On the ventral side are three, rarely four, equal-sized, pointed, erect spines, considerably shorter than the upper large one. A row of smaller spinelets runs down each side of the plate with

a few scattered ones between the larger spines. As on the dorsal paxillae there are no pedicellariae on the infero-marginal plates.

The adambulacral plates have the usual curved, compressed, sabre-like furrow spine, followed by a larger spine also compressed laterally but which appears to be widened near the tip when viewed from a direction parallel to the furrow. A third slightly shorter and narrower spine stands behind this one backed by a three- or even four-valved pedicellaria on the outer edge of the plate. Adoral to the biggest spine there may be a single spinelet like those bordering the infero-marginal plates.

There are no pedicellariae in the furrow on the mouth plates.

The coloration, like that of typical *L. maculata* Müller & Troschel, is blotched. In spirit there are pairs of dark brown marks along the rays. Another specimen has a six-pointed brown star on the centre of the disk and the two small ones have a star effect on the disk caused by a V-shaped dark mark in each interbrachial angle. Many of the ventral spines and spinelets are dark-tipped.

Variations. In the Tuticorin specimen the pedicellaria outside the adambulacral spines is more often than not absent. Also the enlarged central spinelet on the paxillae at the base of the arms may be as much as three times as long as the other spinelets.

The small specimens ($R = c.$ 15 mm.) have very thorny-tipped peripheral spinelets on the dorsal paxillae.

Remarks. This form only seems to differ from typical *L. maculata* in having 6 arms rather than 7–9, besides the conspicuous enlargement of the central granule of the disk paxillae. The latter feature was not encountered by Döderlein and does not occur in the British Museum material of *L. maculata*, although Fisher (1919: 169) says that in eight-armed Philippine specimens the central spinelet is often larger than the others which become progressively smaller towards the periphery of the paxilla. The two forms seem to overlap in their ranges as typical specimens of *L. maculata*, with seven or eight arms and uniform central paxillar granules, have been taken at Tuticorin and on the Pearl Bank, off Ceylon. Unfortunately, no details of locality were recorded at the time. *Luidia maculata* usually has pedicellariae on the marginal and dorso-lateral paxillae but Döderlein says that their presence is very variable and they may be completely absent, as here.

Koehler (1910*a*, pl. 15, fig. 2) shows a figure of the ventral side of a six-armed specimen of *L. maculata* from the Moluccas, but that number seems to have been rarely recorded.

The consistent combination of the two features—presence of only six arms and enlargement of the central spinelet of the disk paxillae—seems to be sufficient grounds for giving this form a special name.

From *Luidia penangensis* de Loriol, a six-armed species also from the Indian Ocean, with an enlarged spinelet in the middle of each paxilla (although not just on the disk and arm-bases), this form can be told at a glance by the absence of a conspicuous madreporite as well as by all the other characters—such as the occurrence of two-bladed pedicellariae on the mouth plates—which distinguish the *Quinaria* group (to which *L. penangensis* belongs), from the *Alternata* group.

QUINARIA GROUP

Luidia hardwicki (Gray)

Pl. 39, Figs. 2 and 3

Petalaster hardwickii Gray, 1840: 183.
Luidia hardwickii, Perrier, 1875: 331 (1876: 251).
Luidia forficifer Sladen, 1889: 258, pl. 44, figs. 5 and 6, pl. 45, figs. 5 and 6; Döderlein, 1920: 278, text-fig. 3, pl. 20, figs. 28 and 29.

Type: R = 32 mm., r = 5·5 mm., R/r = 6/1, br. = 5·5 mm. Registered number 1938.5.12.12. Indian Ocean.

Diagnosis. A species of *Luidia* belonging to the *Quinaria* group, with two or three lateral series of paxillae forming transverse rows with the supero-marginals; large pedicellariae present on the mouth plates and on the outer part of the adambulacral plates; a single enlarged marginal spine at the top of each infero-marginal plate, with smaller appressed spines on the ventral side of the plate.

Description. Three, distally two, rows of lateral paxillae form transverse rows with the supero-marginal series. The inner paxillae are progressively smaller towards the mid-radial line. At the base of the arm there are fifteen paxillae across the width, including the two supero-marginal series. Those in the middle of the ray are, of course, more numerous than the lateral ones, but also tend to be arranged in transverse and longitudinal rows.

These smaller paxillae, both in the centre of the disk and along the rays, have 1–5 central spinelets, resembling slightly elongated granules. On the arms the number is more commonly one and this one may be a little enlarged. On each small paxilla there are also 10–12 peripheral spinelets, 2–3 times as long as wide and only slightly, if at all, thinner than the central ones. The supero-marginal paxillae have up to 10 short central spinelets and about 20 longer peripheral ones. The outermost lateral series have about 8 central and 16 peripheral spinelets.

Pedicellariae seem to be absent from the dorsal side.

The madreporite is concealed by the paxillae.

The ventral side has suffered somewhat in drying, but there is a pair of very long pedicellariae projecting over the furrow from each mouth angle, about 1·5 mm. in length and very similar in size to the larger adambulacral spines. There is a curved, sabre-like furrow spine on each adambulacral plate backed by the usual longer, stouter spine and another spine not as large as the second; the three form a straight row at right angles to the furrow. Adoral to the two outer spines is a very big pedicellaria, about two-thirds as long as the longer spine and with the blades of the valves almost as broad at the tip as at the base (like those of *L. forficifer* as figured by Döderlein (1920: 278, text-fig. 3*a*)).

The ventro-lateral plates are very small, each one forming a little semicircle at the inner end of an infero-marginal plate. They are either bare or only have a few small spinelets. The infero-marginals have two or three appressed spines in a series down the middle of each plate, with smaller spinelets on each side. At the ambitus, which comes just below the small cluster of paxillar spinelets at the uppermost edge of the plate, is a single spine measuring about 1·5 mm. in length and just under 0·5 mm. in width

at the base. Some pedicellariae, about half the size of those on the adambulacral plates, occur on the infero-marginals.

REMARKS. This description agrees very closely with Sladen's of *L. forficifer* (1889: 258) with the exception of the infero-marginal plates, which, in the latter, have five squamiform spinelets in a row, whereas in the type of *L. hardwicki*, these spinelets are fewer and less regularly arranged. The smaller size and poor condition may account, at least partly, for this.

Although the type of *L. forficifer* from 'Challenger' station 187 (Booby Island, Torres Strait) has no pedicellariae on the infero-marginal plates, some are present in a larger co-type from station 188 (Arafura Sea near Torres Strait). There is then no character differing to an extent sufficient to separate the two specifically, so that *forficifer* becomes a synonym of *Luidia hardwicki* (Gray).

British Museum specimens named *L. hardwicki* by Bell, from Macclesfield Bank in the South China Sea, have pedicellariae on many of the dorsal paxillae, not just on the proximal marginal ones as in *L. quinaria.* Such pedicellariae are absent in the types of both *L. hardwicki* and *L. forficifer*, but their presence in other species of *Luidia* is very variable and their occurrence cannot be used as a specific character. These Macclesfield Bank specimens also have relatively few adambulacral plates bearing pedicellariae.

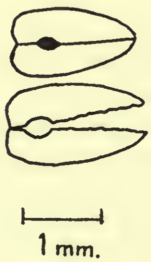
Two specimens from the Great Barrier Reef Expedition, named by Livingstone *L. forficifer*, also have some pedicellariae on the dorsal paxillae.

Luidia quinaria von Martens

TEXT-FIG. 9

Luidia maculata var. *quinaria* von Martens, 1865: 352.
Luidia quinaria, Ives, 1891: 211 pl. 9, figs. 5–9; Döderlein, 1920: 244, 275, text-fig. 1.
Luidia limbata Sladen, 1889: 251, pl. 44, figs. 3–4, pl. 45, figs. 7–8.

One of the ten specimens of *L. quinaria* in the British Museum comes from Hakodate, in northern Japan. The pedicellariae on its mouth plates are rather thick, approximating in shape to those of *L. amurensis* Döderlein (1920: 277, text-fig. 2), from Vladivostok, which is in almost the same latitude as Hakodate.



TEXT-FIG. 9. *Luidia quinaria* von Martens. Pedicellariae from the mouth plates of a specimen from Hakodate, northern Japan.

Also in this specimen, as in *L. amurensis*, the pedicellariae on the marginal paxillae are little bigger than the central granules, not conspicuously larger as in specimens of *L. quinaria* from southern Japan.

The three types of *Luidia amurensis* completely lack pedicellariae on the adambulacral and ventro-lateral plates, but they are present on most of the adambulacral plates in this Hakodate specimen, although these pedicellariae are also relatively thicker than those of *L. quinaria* figured by Döderlein (p. 272, text-fig. 1*b*).

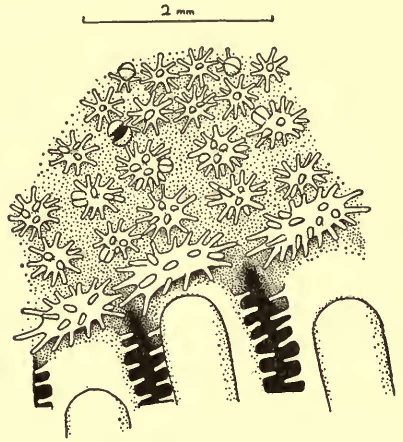
The two forms are obviously very closely related, and *L. amurensis* may be better placed as a northern subspecies of *L. quinaria.*

CILIARIS GROUP

Luidia africana Sladen

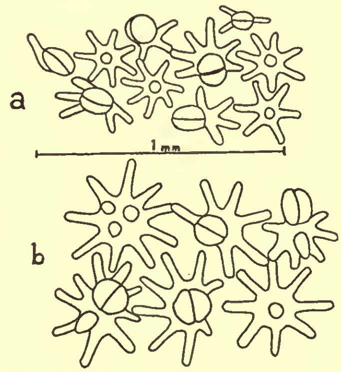
Luidia africana Sladen, 1889: 256, pl. 44, figs. 1 and 2, pl. 45, figs. 1 and 2; Mortensen, 1933*a*: 239, text-figs. 3 and 4; Madsen, 1950: 188, text-fig. 4, pl. 16, figs. 3 and 4.

The types of this species are four specimens from Simon's Bay, South Africa, and one from the coast of Morocco, near Gibraltar. The latter is broken into separate arms and the only complete specimen is a South African one with R = 160 mm. This is the one figured in Sladen's plate 44, although Madsen suspected those illustrations were of the Moroccan specimen, which he thought was more likely to be *Luidia atlantidea* Madsen (1950: 192). Neither of these suppositions is correct. The light stripe along the sides of the arms in the figure of the dorsal side is probably an illusion created by the comparison with the darker mid-radial line. It is impossible to tell after so long in spirit whether such a white stripe, like that of *L. atlantidea*, ever existed in the types of *L. africana*; there is certainly no trace of one now.



TEXT-FIG. 10. *Luidia africana* Sladen. Dorsal view of part of an arm of the 'Challenger' Moroccan specimen.

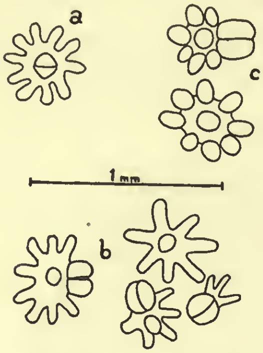
Comparison of the 'Challenger' Moroccan specimen with material of *Luidia atlantidea* and with specimens of *L. sarsi* from European seas as well as the types of *L. africana* from the Cape show that, surprisingly enough, Sladen was probably right in assigning it to the same species as the South African material. The specimen has relatively long, narrow, supero-marginal paxillae, not squarish ones as in *L. atlantidea*. Also the paxillar spinelets are much more slender than in *L. atlantidea*, in which, like *L. sarsi*, they are rather short and thick. The almost spherical pedicellariae are similar in shape and position to those of the other types of *L. africana*, not flattened laterally as shown in Madsen's text-figure 5*d* of the dorsal paxillae of a specimen of *L. atlantidea* (which resembles the North American *Luidia elegans* Perrier in this respect).



TEXT-FIG. 11. *Luidia africana* Sladen. Type specimen from Simon's Bay, South Africa. Dorsal paxillae: (*a*) mid-radial and (*b*) lateral.

As for the presence of pedicellariae, Madsen (p. 191) has emended Mortensen's statement that pedicellariae are absent on the dorsal paxillae of *Luidia sarsi* Düben and Koren by saying that they do occur, but rarely. I have found that out of ten specimens of *L. sarsi* from the north-east

Atlantic examined, four possessed dorsal pedicellariae. One of these from the Shetland Isles has only one, which is on the disk and is centrally placed on a paxilla (Fig. 12*a*). However, in the other three the pedicellariae are peripheral in their position on the paxillae. One from the Orkneys has a few pedicellariae on the lateral and supero-marginal paxillae, another from the Rockall Bank has many, which although still peripheral are spherical, each taking up quite a lot of the surface of the paxilla bearing it (Fig. 12*b*). The last of the four was taken by the 'Triton' and the only locality on the label is 'North Atlantic'. The 'Triton' collected in the Faroe channel, but this specimen may have been taken elsewhere. Its pedicellariae are numerous and again peripherally placed (Fig. 12*c*).



TEXT-FIG. 12. *Luidia sarsi* Düben and Koren. Paxillae of specimens from (*a*) Shetland, (*b*) Rockall Bank, and (*c*) 'North Atlantic' ('Triton').

Another point made by Mortensen (1933*a*: 239, text-fig. 3), which needs some emendment, is that the pedicellariae of *Luidia africana* are situated in the centre of the paxillae with a complete ring of peripheral spinelets around them. I have found that out of eight specimens examined, from various localities around the Cape and including the types, the pedicellariae, when present, are almost invariably eccentrically, if not peripherally, placed on the paxillae. I have not seen a specimen such as Mortensen's in which a perfect, uninterrupted circle of peripheral spinelets surrounds one or more central pedicellariae; in fact none of the specimens in the British Museum has such abundant pedicellariae that there are several on one paxilla. Thus it appears that the location of the pedicellariae centrally on the paxillae cannot be used as a reliable character to distinguish between *L. africana* and the other related species.

Thus in all four species—*Luidia sarsi*, *L. elegans*, *L. atlantidea*, and *L. africana*, the pedicellariae are usually peripherally, or at least eccentrically, placed on the paxillae, although they may be central in some specimens of *L. africana*. The differences between them are relatively slight. *L. atlantidea* has the supero-marginal paxillae almost square rather than nearly twice as long as wide; *L. sarsi* has the uppermost infero-marginal spine usually shorter than the second one, while it is the same length or longer in the other species; *L. elegans* has very numerous pedicellariae which are flattened laterally, and *L. africana* has the paxillar spinelets much longer and more slender than in the other three species. For all this, without knowing the exact locality of an Atlantic specimen of the *Ciliaris* group, it would not be easy to assign it to any one of the four species without abundant material for comparison.

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IV. *TOSIA AND PENTAGONASTER*[1]

AFTER a considerable amount of confusion aroused by the setting up of the compound genus *Astrogonium* by Müller and Troschel in 1842 and later the uncalled-for expansion of *Pentagonaster* by Perrier in 1875 and Sladen in 1889, Gray's two genera *Tosia* and *Pentagonaster* have been gradually restored to their original sense. Verrill (1899) drastically reduced *Pentagonaster* to five species and separated off two sub-genera from the species of *Tosia sensu strictu.* Fisher (1911) recognized the close relationship between the Australasian species of *Tosia* and of *Pentagonaster* as opposed to the other species that had formerly been included with them and so raised Verrill's subgenera of *Tosia* to generic rank. Following Fisher's suggestion I have recently separated off the South African species *Tosia tuberculata* (Gray) as a new genus called *Toraster.*

Ludwig's very comprehensive paper of 1912, although unfortunately without illustrations, has brought more light on Müller and Troschel's species of *Astrogonium,* some of which prove to be identical with Gray's species. Were it not for this paper of Ludwig's, the retention of Gray's probably better-known names *aurata* and *tubercularis* might be possible, but his clarification of Müller and Troschel's previously described species makes it difficult to over-rule them on the counts of unfamiliarity and lack of definition. However, Ludwig based some of his conclusions on inadequate material, and it was not until Livingstone's work in 1932 that the extent of variation of many characters within the genus *Tosia* was realized. From the fairly large number of specimens, including Gray's types, in the British Museum, I am able to add some further remarks.

[1] With the production of this paper immediately after that on *Luidia,* the order of families as used by Fisher has been ignored. However, this is being rectified by reversion to the study of the family Benthopectinidae, with which the next Note (number V) will deal.

The distinction between the genera themselves is practically confined to differences in the pedicellariae, which have long slender valves housed in corresponding grooves in the plates in *Pentagonaster* but are short and rounded, resembling a split granule when closed, if present at all, in *Tosia*. None of the other characters which have been used to distinguish them are absolutely reliable; for instance, the occurrence of swollen distal supero-marginals in *Pentagonaster* is not invariable, whereas it may occur in very marked form in certain specimens of *Tosia australis* and to a lesser extent in the West Australian species *T. nobilis* (Müller & Troschel).

H. L. Clark (1946: 88) mentions *Astrogonium inequale* Gray (1847: 79), which was put in *Pentagonaster* by Perrier and Sladen and whose generic position is in some doubt. Examination of the type, whose locality is given as 'Amboina? New Guinea?', shows that it should be placed in the genus *Sphaeriodicus* Fisher, as it originally had the dorsal, ventral, and marginal plates wholly covered with fine granules (unfortunately mostly rubbed off) and the penultimate marginals are very large, this condition being emphasized by the very small two interbrachial marginals of both upper and lower series. Contrary to Gray's statement there are $\frac{8}{8}$ marginals only on one side of the body, three of the other sides have $\frac{6}{8}$ and there are $\frac{7}{8}$ on the fifth side.

KEY TO THE SPECIES OF *TOSIA* AND *PENTAGONASTER*

1. Pedicellariae with long narrow valves fitting into corresponding grooves in the plates when opened right out (Text-fig. 13); ventro-lateral plates always bare, with only a single ring of granules surrounding each plate. *Pentagonaster* 2

2. Pedicellariae large, the groove of each bivalved one over 1 mm. long, the valves finger-like with slightly swollen ends, occurring mainly on the ventral side, rarely also dorsal; terminal plates small. New Zealand. *P. pulchellus* Gray

2′. Pedicellariae small, tapering, the corresponding groove of each bivalved one about 0·6 mm. long, only in very large specimens nearly 1 mm. long, occurring predominantly on the dorsal side, but often also numerous ventrally; terminal plates large. Australia. 3

3. Supero-marginals not more than five on each side of each arm, distal ones more or less swollen. Western and southern Australia. *P. dubeni* Gray

3′. In some larger specimens more than five supero-marginal plates, the distal ones not swollen or enlarged. South and south-east Australia. *P. dubeni* forma *gunni* Perrier

1′. Pedicellariae if present at all, with short rounded valves, the whole hardly, if at all, larger than the neighbouring granules or spinelets (Text-fig. 14); ventro-lateral plates sometimes completely covered with granules or quite bare with only a bordering row. *Tosia* 4

4. Terminal plate swollen and conspicuous, the distalmost two supero-marginals of each arm not in contact behind it. Queensland. *T. queenslandensis* Livingstone

4′. Terminal plate small and inconspicuous, the last two supero-marginals usually (but not always) in contact. 5

5. Body-form almost a straight-sided pentagon with R/r about 1·3/1 and not more than three supero-marginal plates on each side of each arm. *T. australis* Gray

5′. Interbrachial arcs distinctly concave with R/r more than 1·4/1 or else more than three supero-marginals. 6

6. Number of marginals increasing from three to eight, being three only in specimens with R less than 12 mm., four in those with R about 15 mm., five or more when R is 20 mm. or more. Marginals gradually decreasing in size distally.
T. magnifica (Müller & Troschel)

6′. Number of supero-marginals three or four when R is 20–35 mm., rarely five in specimens larger than that. Often one of the distal supero-marginals is larger than the rest. 7

7. Number of supero-marginals very rarely more than three. Ventro-lateral plates often covered with granules but sometimes bare. Marginal plates swollen and the arms often blunt-ended because of this. South Australia and Tasmania.
T. australis forma *astrologorum* (Müller & Troschel)

7′. Number of supero-marginals often four when R is about 20 mm. or more, even five in larger specimens. Ventro-lateral plates always bare (judging from the known material). Supero-marginal and mid-radial dorsal plates often tubercular or just convex, the marginals relatively narrow in dorsal view. Arms tapering to an acute tip. Western Australia. *T. nobilis* (Müller & Troschel)

PENTAGONASTER Gray

Diagnosis. A genus of the Goniasteridae with more or less pentagonal body form; the dorsal and marginal plates flat or convex, not tabulate or spiny, the limits of these and also of the ventral plates, outlined by single rows of peripheral granules; the marginal plates very large, often, but not always, somewhat tubercular or swollen, especially the distal ones; pedicellariae with two or three elongated valves sunk into corresponding grooves in the plates bearing them; adambulacral armature very short and compact, so that the furrow spines and the granules behind them tend to be angular. Australasia. Type: *Pentagonaster pulchellus* Gray, 1840.

Pentagonaster pulchellus Gray

Text-fig. 13*a*, Pl. 42

Pentagonaster pulchellus Gray, 1840: 280; 1866: 11, pl. 8, fig. 3; Ludwig, 1912: 9; Mortensen, 1925: 281, text-fig. 7, pl. 12, fig. 6–10.
Stephanaster elegans Ayres, 1851: 118.
Pentagonaster abnormalis Gray, 1866: 11, pl. 8, figs. 1 and 2.

Diagnosis. A species of *Pentagonaster* with large pedicellariae, of which the corresponding grooves in the plates measure 1·2–1·7 mm. in length and which are situated exclusively or mainly on the ventral plates, rarely on the dorsal side; three supero-marginal plates on each side of an arm or the large, occasionally swollen distalmost one is replaced by two, often more or less unequal ones; in very large specimens the supero-marginals may become separated from each other by small interstitial plates of similar size to the neighbouring dorso-lateral plates; the infero-marginals outnumber the upper series but they correspond in position to the supero-marginals

almost exactly, except for the one or two extra distal plates which are abruptly smaller than the one which lies below the distalmost supero-marginal; granules surrounding the ventral plates coarse and usually projecting from the under surface of the body; in specimens with R = 40 mm. or more there are a number of secondary plates on the dorsal side near the centre of the disk.

Table of the specimens of Pentagonaster pulchellus *in the British Museum*

Reg. No.	*R/r in mm.*	*Locality*	*Remarks*	*Size of distal supero-marginals*
1938.6.23.43	59/35 = 1·7/1	'China'	TYPE	4
48.2.9.3	34/20 = 1·7	'India'	TYPES of	2
48.2.9.2	45/24 = 1·9	,,	*abnormalis*	1
55.3.31.9	31/18 = 1·7	New Zealand		3
55.3.31.10	14/9 = 1·6	,,		3
55.3.31.10	15/10 = 1·5	,,		3
49.12.19.2	33/19 = 1·7	,,		4
49.12.19.3	29/18 = 1·6	,,		1
52.5.21.19	62/38 = 1·6	,,		3
52.5.21.20	45/29 = 1·6	,,		3
75.1.5.20	39/22·5 = 1·7	,,		2
44.4.29.130	34/21 = 1·6	,,		1
84.12.18.1	50/31 = 1·6	'Australia'		3
51.3.12.17	33/19 = 1·7	'China'		4
1949.2.4.2	60/40 = 1·5	,,		3
1949.2.4.2	62/41 = 1·5	,,		2
1949.2.4.2	55/35 = 1·6	,,		3
1949.2.4.2	44/26·5 = 1·8	,,		1
1949.2.4.2	43/29 = 1·5	,,		2
1949.2.4.2	58/36 = 1·6	,,		1
1949.2.3.2	35/22 = 1·6	No data		4
1949.2.3.2	31/18 = 1·7	,,		2

Range of R/r = 1·5–1·9. Average = 1·6/1.

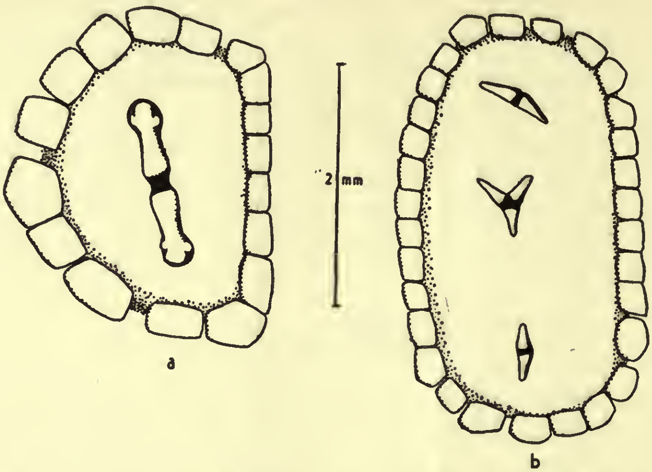
Note: The numbers in the last column signify grades of swollenness of the last supero-marginal on each side of each arm, 1 being not swollen (as in Pl. 42, fig. 2) and 4 very swollen (as in Gray's figure of the type).

REMARKS. Mortensen has given a detailed description and photographs of this species, of which his plate 12, fig. 9, most resembles the type, although the majority of specimens have the less extreme form with only slightly swollen distal supero-marginals, as shown in his figs. 7 and 8.

Nine of the above specimens are definitely from New Zealand; the 'Chinese' and 'Indian' ones were possibly so labelled by vendors thinking that an exotic locality would fetch a better purchasing price than none! Although one specimen is labelled as coming from Australia, no details are given and it may be a mistake; certainly it does not provide sufficient grounds for extending the known range of the species from New Zealand to Australia. A specimen from Tasmania formerly named *P. pulchellus* turned out to be a form of *Tosia australis* with very swollen distal supero-marginals (Pl. 45, fig. 1). It was easily distinguished by the lack of pedicellariae on the ventral plates and the much finer peripheral granules, as well as the absence of secondary

plates (except the anal) among the primaries in the centre of the disk. Also the five primary interradial plates are conspicuously enlarged in contrast to the usual condition in *P. pulchellus*.

The only other observation I have to make concerning this species is the fact that in three out of the six spirit specimens from 'China' mentioned above, the mid-radial row of dorsal plates as well as a few others are more or less markedly elevated into quite conspicuous tubercles about 3 mm. high, just as in the type of H. L. Clark's species *Pentagonaster stibarus* from Western Australia (1914, pl. 17). That these



TEXT-FIG. 13 (*a*) *Pentagonaster pulchellus* Gray, type, a ventral plate with a pedicellaria. (*b*) *Pentagonaster dubeni* Gray, type, a dorsal plate with three pedicellariae.

specimens are not identical with that form is shown by the fact that the pedicellariae are on the ventral side rather than the dorsal. I give here a photograph of the specimen which shows this 'tubercular' condition most clearly (Pl. 42, fig. 5).

RANGE: New Zealand—South Island and southern part of North Island; Stewart Island; ? Chatham Islands.

Pentagonaster dubeni Gray

TEXT-FIG. 13*b*; PLS. 43 and 44

Pentagonaster dubeni Gray, 1847: 79; 1866: 11, pl. 3, fig. 2; Ludwig, 1912: 18; H. L. Clark, 1928: 380; Livingstone, 1932, pl. 44, figs. 4 and 5; H. L. Clark, 1938: 79; 1946: 88.
Astrogonium crassimanum Mobius, 1859: 8, pl. 2, figs. 1 and 2.
Pentagonaster crassimanus, H. L. Clark, 1946: 89.
Pentagonaster gunni Perrier, 1875: 203 (1876: 19).
Pentagonaster stibarus H. L. Clark, 1914: 136, pl. 17.

DIAGNOSIS. A species of *Pentagonaster* with small pedicellariae, the corresponding grooves in the plates 0·4–0·9 mm. in length, usually about 0·6 mm., lying on both

dorsal and ventral sides as a rule, rarely few in number and absent ventrally; supero-marginal plates four to eight on each side of an arm, the distal ones more or less swollen, especially when there are only four or five; the infero-marginal plates invariably outnumber the upper series by about two plates and decrease gradually in size distally; the granules surrounding the ventral plates fine and unobtrusive; adambulacral armature compact; few, if any, secondary plates interposed among the primary ones in the centre of the disk, even when R is as much as 40 mm.

Table of the specimens of Pentagonaster dubeni *Gray in the British Museum* (*Nat. Hist.*)

Reg. No.	*R/r in mm.*	*Number and condition of supero-marginal plates*	*Locality*	*Number*	*Remarks*
46.6.7.27	37/18 = 2·1/1	5. The last two a little enlarged and swollen	W. Australia	1	TYPE
60.11.7.5	48/20 = 2·4	5. Penultimate largest but not swollen	Freemantle, W.A.	1	—
52.12.9.20	37/16 = 2·3	4. Last 1 or 2 enlarged and very swollen	Moreton Bay, Queensland	1	? *dubeni*
49.11.19.163	47/18 = 2·6	8. Last smaller but rest all same size	Georgetown, Tasmania	1	TYPE of *P. gunni*
1951.2.28.1–11	41/17 = 2·4 to 22/10 = 2·2	4 (rarely 3 or 5). Last 1 (or 2) swollen	Point Peron & Garden Island, W.A.	19	—

REMARKS. H. L. Clark queries the locality of the type on the basis that as 'China' was wrong for the type of *Pentagonaster pulchellus*, so might 'Western Australia' be wrong for that of *P. dubeni*. This may be so, but the locality is supported by the Freemantle specimen collected by Dr. Bowerbank, which has convex dorsal plates and five supero-marginals like the type, although all the recent Point Peron and Garden Island specimens have more than four only on individual sides. I am indebted to Miss L. Rutt of the Biology Department, University of Western Australia, who collected and sent these specimens at my request. They are very similar in appearance to the type of *P. stibarus* H. L. Clark, from between Freemantle and Geraldton in 40–100 fathoms, except for slightly deeper interbrachial arcs and the absence of the tubercular mid-radial plates found in the latter. H. L. Clark has since reduced his species to a synonym of *P. crassimanus* (Mobius), the type of which was of problematical locality. Ludwig gives the R/r ratio of the type of *P. crassimanus* as 1·84/1; that of *P. stibarus* is 2/1, while the value for the Western Australian specimens in the British Museum varies between 2 and 2·4/1.

Some of the Point Peron and Garden Island specimens have slightly convex mid-radial plates, but in the type and the Freemantle specimen nearly all the dorsal plates are markedly convex. Apart from this character, which is very variable in *Pentagonaster* and related genera, there is no feature of sufficient significance to distinguish between the *stibarus*-like form and the type of *P. dubeni*. Ludwig's fuller description of the type of *P. crassimanus* brings out no detail, except perhaps for the shorter arms, in which it differs significantly from the type of *P. dubeni*, although Ludwig sets out five distinguishing points as follows: *P. crassimanus* has (1) wider arm-tips, (2) fewer supero-marginals relative to the absolute size, (3) the distal

supero-marginals more swollen, (4) the bordering granules around the plates coarser, and (5) the adambulacral spines more compact than in *P. dubeni*. Of these, factors 1 to 3 are very variable and utterly useless as specific characters in this genus, 5 is unlikely as the adambulacral armature of the type of *P. dubeni* is already very compact and 4 is probably not significant either, at least without direct comparison of specimens.

There are three furrow spines on each adambulacral plate in the type of *P. dubeni* and in all the larger (i.e. over 40 mm. R) specimens in the British Museum. The fact that those of adjacent plates tend to overlap may have given rise to the discrepancy in the numbers given by some authors. Smaller specimens have only two furrow spines at least distally.

H. L. Clark (1946), believes there is a specific difference between the Western Australian form, which he calls *P. crassimanus*, and the southern Australian form, which he calls *P. dubeni*, evinced mainly by the larger number of dorsal and ventral plates in juvenile specimens of the southern form than in others the same size from Western Australia. This difference does not seem to be shown in the adult, at least judging from the comparison of the type of *P. dubeni* with that of *P. gunni* from Tasmania, which is unfortunately the only specimen from the south in the British Museum collection. The type of *P. gunni* also shows the other feature which H. L. Clark noticed in his material from the South Australian Museum, namely that there may be more than five supero-marginals on each side of an arm in larger specimens and these become smaller distally. When there are only about five plates though, the distal ones may be swollen and larger than the interradials. H. L. Clark's specimen with most supero-marginal plates had seven on each side and R was 54 mm., whereas the type of *P. gunni* has eight with R = only 47 mm. and so is even more extreme.

Miss Rutt has provided some colour notes for the specimens from Point Peron and Garden Island, south of Freemantle. These were collected just below low-water level among seaweed on rock platforms. The colour was very variable, ranging through pale flesh-pink, deeper salmon-pink, pale brick-red, light orange, brilliant crimson, and bright orange, the last being the commonest. The granules between the plates were white. H. L. Clark gives bright vermilion, with white between the plates for a specimen from Port Jackson, New South Wales.

Since *Pentagonaster dubeni* is preoccupied for the Western Australian form, the southern form, if specifically distinct, will have to be called *P. gunni*, but with the present sparse material and the conspicuous gap geographically in our knowledge of the species along the south Australian coast westwards towards Albany and Bunbury, it seems best to leave them as a single species *P. dubeni* for the present.

Possibly *crassimanus* can also be retained as a name for the short-armed form of *dubeni* from deeper water (40–100 fathoms) off Western Australia.

As for the Queensland specimen, this is superficially very similar to the type of *P. dubeni* but it has very sparse pedicellariae (five or six on the dorsal side only), which are even smaller than in the other specimens, measuring only 0·4 mm. in length. Also the supero-marginal (particularly the distal) plates and the dorsal plates have a roughened surface like those of Livingstone's species *Tosia queenslandensis*, known

only from juvenile specimens without pedicellariae. Here again more material is wanted which I think will indicate that that species would be better placed in the genus *Pentagonaster* and that this specimen represents the adult form of it.

RANGE. Western, southern, and south-eastern Australia; ? Queensland.

TOSIA Gray

DIAGNOSIS. A genus of the Goniasteridae with the body more or less pentagonal in form having a limited number (three to eight) of supero-marginal plates on each side of each arm; the dorsal and marginal plates flat or convex and bare but for one (rarely two) rows of bordering granules; ventro-lateral plates similarly bare or more or less completely covered with additional granules; the five primary plates of the dorsal side usually conspicuously larger than the other dorsal plates; adambulacral plates with two (three in large specimens) short spines in each of the two rows nearest the furrow, backed by several rows of granules; pedicellariae, if present at all, with two short, wide valves, the whole not or hardly larger than one of the surrounding granules, situated on either dorsal or ventral side, particularly on the adambulacral plates. Australia and Tasmania. Type: *Tosia australis* Gray 1840.

REMARKS. The synonymy of the species within this genus is in a very muddled state owing to the ignoring of Müller and Troschel's species by Gray and the failure of these authors to realize the extent of variation in the granulation of the ventral plates and in the concavity of the interbrachial arcs as well as the increase in the number of marginal plates with size in some of the species (particularly *T. magnifica*). Livingstone (1932: 373) has detailed the variation of these characters in the different species. Unfortunately he did not have access to Ludwig's paper of 1912, which sheds much light on Müller and Troschel's type specimens, consequently necessitating some departure from Gray's specific names which I have further emended here.

Original name	*Ludwig's emendment*	*Present view*
australis Gray, 1840	Valid	Valid
magnifica (Müller & Troschel), 1842	Valid	Valid
astrologorum (Müller & Troschel), 1842	= *australis*	forma of *australis*
geometricum (Müller & Troschel), 1842	= *australis*	= *australis*
australe, (Müller & Troschel), 1842	—	= *magnifica*
ornata (Müller & Troschel), 1842	= *australis*	= *magnifica*
nobilis (Müller & Troschel), 1843	Valid	Valid
grandis Gray, 1847	= *magnifica*	= *magnifica*
aurata Gray, 1847	Valid	= *magnifica*
tubercularis Gray, 1847	= *nobilis*	= *nobilis*
rubra Gray, 1847	= *australis*	= *nobilis*
emilii (Perrier), 1869	= *aurata*	= *magnifica*
minimus (Perrier), 1875	—	juvenile *australis* or *nobilis*
queenslandensis Livingstone, 1932	—	Valid. *Pentagonaster* ?

Most adult specimens of the genus *Tosia* can be quite easily identified, but juvenile specimens, particularly of *T. nobilis* and *T. australis*, can be confused.

Tosia australis Gray[1]

TEXT-FIG. 14, PL. 45, FIGS. 1 and 2, PL. 46, FIG. 3.

Tosia australis Gray, 1840: 281; 1866: 11, pl. 16, fig. 1; Verrill, 1899: 160; Ludwig, 1912: 23; H. L. Clark, 1928: 381; Livingstone, 1932: 375, pl. 43, figs. 10–13, pl. 44, fig. 6; H. L. Clark, 1946: 94. [non *Astrogonium australe*, Müller and Troschel, 1842: 55.]
Pentagonaster australis, Perrier, 1875, 200 (1876: 16).
Astrogonium astrologorum Müller and Troschel, 1842: 54.
Pentagonaster astrologorum, Perrier, 1875: 196 (1876: 12).
Tosia australis var. *astrologorum*, H. L. Clark, 1928: 384; Livingstone, 1932: 376.
Astrogonium geometricum Müller and Troschel, 1842: 54.
Tosia tubercularis, Livingstone, 1932: 378, pl. 44, figs. 1, 2, and 7. [non *Tosia tubercularis* Gray, 1847: 80.]

DIAGNOSIS. A species of *Tosia* with three (rarely four) supero-marginal plates on each side of each arm, of which the distalmost may or may not be enlarged; the dorsal plates usually flat, but in some specimens, particularly from Tasmania, the dorsal and supero-marginal plates may be markedly convex; pedicellariae sometimes present but only in small numbers, on either dorsal or ventral side, often only on a few of the adambulacral plates; body form typically almost a straight-sided pentagon with $R/r = c.\ 1{\cdot}35/1$, but in the forma *astrologorum* the interbrachial arcs can be much more concave so that the R/r ratio may exceed $1{\cdot}5/1$.

REMARKS. There are fifty-two specimens of *Tosia australis* in the British Museum, of which twenty-six are detailed in the table on p. 405. The first specimen listed, 43.3.10.26 (Pl. 45, fig. 2; Pl. 46, fig. 3), is the one figured by Gray and is therefore presumably the type although not labelled as such.

Unlike *Tosia magnifica* the number of supero-marginal plates does not normally increase with size, so that with the single exception of one of the 'Challenger' specimens from Sydney Harbour (Port Jackson), all of these have only three supero-marginal plates on each side of each arm. The exception has four on most sides. The locality or identity of these 'Challenger' specimens has been queried by Livingstone on the grounds that no further material of this species has since been found in Port Jackson. Sladen named the specimens *Pentagonaster astrologorum* (Müller and Troschel). They are not young *P. dubeni* as Livingstone suggested might be the case, as for one thing the terminal plates are very small. The collector's label within the jar clearly says 'Sydney Harbour'. The dimensions are as follows: R/r in mm. $= 19/12{\cdot}5 = 1{\cdot}5/1$; $18/13 = 1{\cdot}4/1$; $16/10{\cdot}5 = 1{\cdot}5/1$; $15/10 = 1{\cdot}5/1$; $14/9 = 1{\cdot}6/1$; and $10{\cdot}5/7{\cdot}5 = 1{\cdot}4/1$. It is only the largest one which has four supero-marginals. The ventral plates in every case are completely covered with granules, and each specimen has at least one rounded pedicellaria on the ventral side, usually near the mouth. The marginal plates are slightly swollen.

[1] The *Asterias procyon* of Valenciennes (manuscript), published by Cuvier in the *Règne Animal* (Disciples edition) vol. **20**: Zoophytes, pl. 1, fig. 2, is either this species or *Tosia nobilis*, more probably the latter since it is said to have been collected by Quoy and Gaimard in King George's Sound, south-western Australia, although in appearance it is rather more like *T. australis*. The date of this publication is presumed to be 1838 (see Sherborn, 1922, *Ann. Mag. Nat. Hist.* (9) **10**: 555). It is surprising that neither Müller and Troschel nor Perrier, all of whom probably had access to Valenciennes manuscript, do not quote this species. Since it is not positively identifiable it should be declared a *nomen nudum*.

Table of the specimens of Tosia australis *Gray in the British Museum (Nat. Hist.)*

(Those below the dividing line belong to the forma *astrologorum*)

Reg. No.	*R/r in mm.*	*Number of infero-marginals*	*Locality*
43.3.10.26	23·5/18 = 1·3/1	5	—
40.10.17.87	19·5/14 = 1·4	5	—
53.11.22.33	22/18 = 1·2	4	Australia
53.11.22.31	22/17 = 1·3	5	,,
85.11.19.43	15/12 = 1·25	4	Port Phillip Heads
63.9.23.43*a*	16/13 = 1·2	4	Australia
90.5.7.393	19/12·5 = 1·5	5	Sydney Harbour
90.5.7.394	18/13 = 1·4	4	,,
62.7.9.55	20/15 = 1·3	5	Dirk Hartog Island, W.A.
62.7.9.69	14/10·5 = 1·3	4	,,
57.3.20.15	17/13 = 1·3	4	Port Dalrymple, Tasmania
54.11.15.304	20/14 = 1·4	5	,,
54.11.15.304*a*	17/12 = 1·4	4	,,
40.3.9.2	17/12 = 1·4	4	Tasmania
62.1.8.20	27/19 = 1·4	6	,,
62.1.8.21	25/20 = 1·3	5	,,
49.11.19.159	20/14 = 1·4	5	Georgetown, Tasmania
49.11.19.146	17/13 = 1·3	4 (5)	,,
49.11.19.158	20/15 = 1·3	4	,,
49.11.19.155	20/13 = 1·5	5	Georgetown, Tasmania
49.11.19.156	19/13 = 1·5	5	,,
49.11.19.153	30/20 = 1·5	6	,,
1916.8.10.1	23/17 = 1·4	4 (5)	Tasmania
62.1.8.19	30/19 = 1·6	6	,,
40.10.17.88	22/15 = 1·5	6	—
43.3.10.26*a*	32/21 = 1·5	5	—

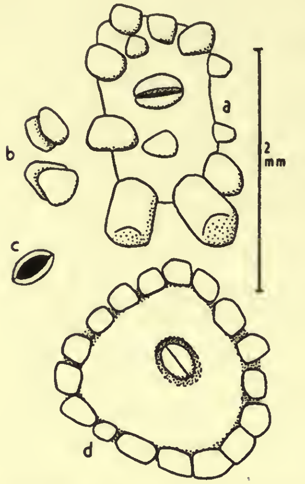
The occurrence of pedicellariae in the species *Tosia australis* seems to be a matter of some doubt. Livingstone says that pedicellariae are absent in typical *T. australis* and in the variety *astrologorum*, at least on the ventral side of the latter. Ludwig found pedicellariae on the dorsal side of five out of fourteen specimens. I also have found them on the dorsal side of at least five specimens of *T. australis* and on the ventral side of ten (three specimens having them on both sides), besides the six 'Challenger' specimens.

Livingstone figures a specimen from Victoria (pl. 44, figs. 1, 2, and 7), which he calls *T. tubercularis* Gray (i.e. *nobilis*). It does not belong to that species, which is confined to Western Australia, but should instead be named *T. australis* forma *astrologorum* although it has four supero-marginals. There are several specimens in the British Museum intermediate in form between this Victorian one and the more usual type as shown in Livingstone's pl. 43, figs. 1 and 2, which he acknowledges as *astrologorum*.

Ludwig also had some specimens which he considered to be *Tosia australis* with four supero-marginals, although most of his had the usual three.

Müller and Troschel's as well as Perrier's descriptions of the types of *astrologorum* leave room for some doubt that their specimens were not the Western Australian species to which the first-named authors gave the name *Astrogonium nobile* in 1843

(p. 116). The description and locality of the type of the latter show that it is undoubtedly identical with Gray's *Tosia tubercularis* described in 1847. Perrier (1875: 197) gives the measurements of the largest Parisian type of *astrologorum* as $R/r = 35/21 = 1{\cdot}67/1$. Müller and Troschel write that the last of the three supero-marginal plates is very large and corresponds to three infero-marginals which could apply either to *T. nobilis* or to the longer-armed form of *T. australis*. However, the fact that there may be up to seven infero-marginals corresponding to the three supero-marginals according to Perrier is rather more conclusive in pointing to the identity of *astrologorum* with *T. nobilis*, for only in the latter have I found more than six infero-marginal plates, the number being habitually seven for specimens with R more than 30 mm. Perrier also says that there may be a very small distal fourth supero-marginal, which again indicates the Western Australian species.



TEXT-FIG. 14. *Tosia australis* Gray, specimen 49.11.19.158. (*a*) Proximal adambulacral plate with non-sunken pedicellaria. (*b*) Other adambulacral pedicellariae. (*c*) Foramen of pedicellaria of which the valves have been rubbed off. (*d*) Ventral plate with pedicellaria sunk in a hollow.

However, these points are not sufficiently conclusive to abandon, without examination of the types, the now fairly stabilized conception of *astrologorum* as a longer-armed form of *Tosia australis* with more or less swollen marginal plates.

The record of typical *Tosia australis* from Dirk Hartog Island, Sharks Bay, about 450 miles north of Freemantle, needs confirmation from more recent collections.

RANGE. Both the typical form and *astrologorum* appear from various reports to occur in South Australia, Victoria, and Tasmania and possibly also from Port Jackson. The British Museum material suggests that the latter is most common in Tasmania.

Tosia nobilis (Müller and Troschel)

PL. 45, FIGS. 3, 4, 6, and 7; PL. 46, FIGS. 1 and 2

Astrogonium nobile Müller and Troschel, 1843: 116.
Tosia tubercularis Gray, 1847: 80; 1866: 11, pl. 16, fig. 4. [non *Tosia tubercularis* Livingstone, 1932: 378, pl. 44, figs. 1, 2, and 7.]
? *Tosia rubra* Gray, 1847: 81; 1866: 11, pl. 16, fig. 3; Livingstone, 1932: 380.
Tosia nobilis, Ludwig, 1912: 30.

DIAGNOSIS. A species of *Tosia* with evenly tapering arms; three to five supero-marginal plates on each side of each arm, the distalmost, or more rarely the penultimate, elongated when there are three or four, or subdivided in very large specimens to make five with the distalmost the smallest; dorsal plates, particularly the radial ones, conspicuously convex, as are the supero-marginals, although the latter are not

much swollen laterally and are usually relatively narrower than those of *Tosia australis*; the convexity of the supero-marginals may assume a conical form with a distinct peak on each plate; interbrachial arcs rather deep with R/r usually more than 1·5/1; ventro-lateral plates usually (? always) bare. Western Australia.

Table of the specimens of Tosia nobilis (*Müller and Troschel*) *in the British Museum* (*Nat. Hist.*)

(The first two are the types of *T. tubercularis* Gray and the last one the type of *T. rubra* Gray)

Reg. No.	*R/r in mm.*	*Number of supero-marginals*	*Number of infero-marginals*	*Locality*
46.8.14.3	30/18 = 1·7/1	4	6	Swan River, W.A.
46.8.14.4	25/16 = 1·6	3	6	,,
46.8.14.5	16/12 = 1·3	3	5	,,
63.9.23.43	11/7 = 1·6	4	5	'Australia'
60.11.7.8	20/14 = 1·4	3	6	Freemantle, W.A.
60.11.7.9	21/14 = 1·5	3	6	,,
61.7.8.25	23/14 = 1·6	4	6	,,
61.7.8.26	19/12·5 = 1·5	3	5	,,
61.7.8.27	18/12 = 1·5	3 (4)	5	,,
46.6.7.28	24/16 = 1·5	4	6	Western Australia
72.6.22.21	29/17 = 1·7	5 (4)	7	—
40.10.4.2	18/11 = 1·6	4	6	'New Holland'
1949.2.3.6	32/21 = 1·5	4	7	—
1951.4.3.1	22/14 = 1·6	3 (4)	6	—
1951.4.3.1*a*	20/12·5 = 1·6	4	6	—
1951.2.28.12–17	39/24 = 1·6	5	7 (8)	Garden Island, south of Freemantle, W.A.
,,	37/23·5 = 1·6	3	7	,,
,,	36/20·5 = 1·8	4	7	,,
,,	35/21 = 1·7	3	7	,,
,,	30/18 = 1·7	3 (4)	7	,,
,,	27/18 = 1·5	3	7	,,
,,	25/15 = 1·7	4	5 (6)	,,
,,	25/17 = 1·5	3 or 4	6	,,
,,	20/13 = 1·5	4	6	,,
,,	20/13 = 1·5	3	5	,,
1938.5.12.10	33/20 = 1·7	5	7	'Australia'

Average R/r = 1·6/1.

REMARKS. The material in the British Museum suggests that *Tosia nobilis* grows to a larger size (R = up to 40 mm.) than *Tosia australis*, of which the typical form rarely exceeds R = 24 mm. and the forma *astrologorum* about R = 33 mm. However, more material may serve to disprove this statement.

Further material from Garden Island, sent by Miss Rutt, includes three specimens with R = *c.* 35 mm., one with three supero-marginals, another with four, and the third with five, which shows the variability of this character in *Tosia nobilis*. There is also a specimen with six regular arms.

Livingstone's specimens, which he called *Tosia tubercularis*, originated from Victoria and in spite of the relatively deep interbrachial arcs are quite distinct from the Western Australian form, judging from his photographs. They should instead be assigned to the forma *astrologorum* of *Tosia australis*. The differences between the

two are rather intangible and can be better expressed by photographs than words. The arms are invariably evenly tapering with only a slight rounding of the tip in *T. nobilis*, although they may be so in some specimens of *astrologorum* too; also the supero-marginals tend to be relatively narrower in *T. nobilis* than in most examples of *astrologorum*. With a large number of specimens of both forms, it is fairly easy to pick out the Western Australian ones, but without such material for comparison some difficulty may be encountered. Whereas *T. nobilis* is geographically distinct from typical *T. australis* unlike *astrologorum*, it might be better to consider it as a subspecies of *Tosia australis*, if the differences are not thought to be specific.

The ventro-lateral plates (at least proximally) are in every case bare but for the single peripheral ring of granules around each. It was this which finally prompted me to include *Tosia rubra* Gray as a synonym of *T. nobilis* rather than of *T. magnifica*; for although the type of the latter, from Tasmania, had the ventral plates quite bare, in all but one of the specimens in this Museum only the proximal plates, if any, are bare, or else there is a double row of granules around each plate. The type of *T. rubra* has the ventral plates bare like *nobilis*. Of the five supero-marginal plates none is enlarged and the distalmost is the smallest, as in *T. magnifica* but also as in those specimens of *T. nobilis* which do have five marginals. It is linked with *Tosia nobilis* by another specimen, number 1949.2.3.6 (Pl. 45, fig. 7), which has four supero-marginals, the penultimate being enlarged. Unfortunately neither of these two has any locality other than 'Australia'. It is to be hoped that more of these intermediate forms between *Tosia nobilis* and *T. magnifica* on the one hand, or *T. australis* forma *astrologorum* on the other, will be forthcoming in future collections to clarify the position.

Livingstone reports some specimens, which he includes under *Tosia australis*, from King George's Sound and Esperance at the western end of the south coast of Australia. Material from this area should be very interesting, possibly connecting up *Tosia australis* with *T. nobilis*, but unfortunately the Australian Museum specimens from these localities are all juvenile.

RANGE. Known at present only from Western Australia in the vicinity of Freemantle.

Tosia magnifica (Müller and Troschel)

PL. 45, FIG. 5; PL. 46, FIGS. 4 and 5

Astrogonium magnificum Müller and Troschel, 1842: 53, pl. 4, fig. 1.
Astrogonium australe, Müller and Troschel, 1842: 55.
Astrogonium ornatum Müller and Troschel, 1842: 55.
Tosia grandis Gray, 1847: 80; 1866: 11, pl. 3, fig. 1; Livingstone, 1932: 380.
Tosia aurata Gray, 1847: 80; 1866: 11, pl. 16, fig. 2; Ludwig, 1912: 34; Livingstone, 1932: 377, pl. 43, figs. 3–9, pl. 44, fig. 3.
Astrogonium emilii Perrier, 1869: 84.
Pentagonaster auratus, Perrier, 1875: 204 (1876: 20).
Tosia magnifica, Ludwig, 1912: 36.

DIAGNOSIS. A species of *Tosia* with evenly tapered arms, the distalmost supero-marginals showing no tendency for enlargement or swelling, being usually smaller than the penultimates; the number of marginals tends to increase with size up to eight on

each side of each arm in specimens where R = about 70 mm. and even young specimens with R = only 10 mm. have often four, rather than three, supero-marginals; ventro-lateral plates usually covered with granules, but sometimes more or less bare especially the proximal ones.

Table of the specimens of Tosia magnifica (*Müller and Troschel*) *in the British Museum* (*Nat. Hist.*)

Reg. No.	*R/r in mm.*	*Number of supero-marginals*	*Locality and remarks*
43.11.2.134	27/18 = 1·5/1	6	— TYPE of *Tosia aurata*
43.11.2.134*a*	20/14 = 1·4	5	— TYPE of *Tosia aurata*
1938.5.12.9	77/51 = 1·5	8	Western Australia? TYPE of *Tosia grandis*
1938.5.12.21	60/37 = 1·6	7	Georgetown, Tasmania
62.1.8.17	52/35 = 1·5	6 or 7	Tasmania
87.12.7.1	52/38 = 1·4	6	,,
87.12.7.1*a*	31/22·5 = 1·4	5	,,
85.11.19.41	62/37 = 1·7	7	Port Phillip Heads
54.11.15.305	15/10 = 1·5	5	Hobson Bay, Port Phillip
54.11.15.306	6·5/5·5 = 1·2	3	,,
1916.8.10.4	20/14 = 1·4	6	South Australia
1949.2.3.4	13·5/10 = 1·4	4	Adelaide, S. Australia
1949.2.3.4*a*	13·5/9·5 = 1·4	4	,,
1949.2.3.4*b*	12/8·5 = 1·4	4	,,
1949.2.3.4*c*	14/11 = 1·3	3 or 4	,,
1949.2.3.4*d*	11/9 = 1·2	4	,,
1949.2.3.4*e*	10/7·5 = 1·3	3 or 4	,,
1949.2.3.4*f*	10·5/7·5 = 1·4	4 (3)	,,
43.3.10.27	29/20 = 1·5	5	—
1949.2.3.5	31/21 = 1·5	6	—
49.11.19.143	37/24 = 1·5	7	Georgetown, Tasmania
49.11.19.140	50/30 = 1·7	5 (6)	,,
49.11.19.140*a*	30/21 = 1·4	6	,,
49.11.19.140*b*	37/25 = 1·5	7	,,
49.11.19.142	42/29 = 1·5	6	,,

Average R/r for specimens with R more than 15 mm. = 1·5/1.

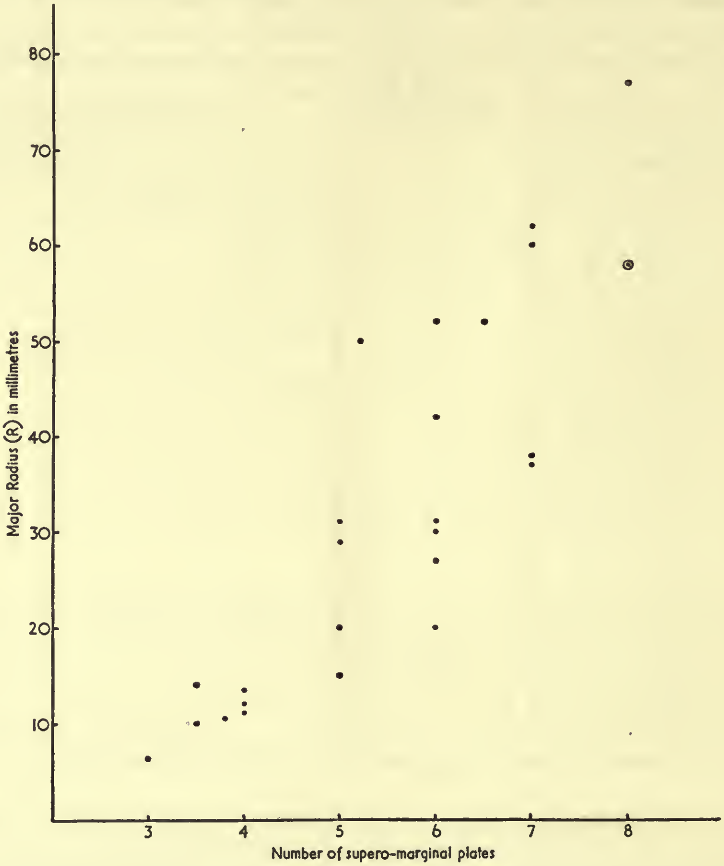
REMARKS. The multiplicity of names given to this species resulted from the independent setting up by Gray of new species for the forms already described by Müller and Troschel, besides the ignorance of both parties concerning the extent of variation in the ventral granulation and the increase in the number of marginal plates with size.

The big range of specimens in the British Museum shows that, as Livingstone suspected, the large form (described as *magnifica* and *grandis*) is clearly conspecific with the small one (*ornata-aurata*). *Magnifica* has page priority over Müller and Troschel's other name.

Livingstone queries the inclusion by Perrier of Müller and Troschel's *Astrogonium australe* as a synonym of this species on the grounds that they give the number of supero-marginals as six. However, those authors give the number for *A. geometricum* (*australis*) as three, so obviously they were counting the numbers on each side of each *arm* not on each side of the body, as Livingstone does.

In most of the specimens that I have seen, the majority, if not all, of the ventral

plates are completely covered with granules. Sometimes a single plate in some interradii near the mouth is bare, more often there are eight or nine bare plates in each interradius, each one usually surrounded by a double row of granules. In general the incidence of ventral granules is much higher in this species than in *Tosia nobilis* or *T. australis*, particularly the former.



TEXT-FIG. 15. Graph to show the increase in the number of superomarginal plates with absolute size in *Tosia magnifica*, based on specimens in the British Museum except for the point ringed, which represents Müller and Troschel's type.

It is partly this predominance of ventral granules which leads me to include *Tosia rubra* Gray as a synonym of *T. nobilis* rather than of *T. magnifica*, although the abundance of granules is by no means diagnostic, the type of *T. magnifica* having nearly all the ventral plates bare.

Although the number of marginal plates increases in general with size, there is considerable variation in different individuals, as can be seen from the table. However, very young ones with the major radius R as small as 10 mm. usually have some,

if not all, the arms with four supero-marginals on each side in contradistinction to juveniles of the other species of *Tosia*, which do not have more than three.

RANGE. Victoria, Tasmania, and South Australia.

Tosia queenslandensis Livingstone

Tosia queenslandensis Livingstone, 1932*a*: 243, pl. 5, figs. 1, 2, and 7; 1932: 381, pl. 44, fig. 3.

There is a paratype in the British Museum, but like the type it is juvenile. Neither of these have pedicellariae according to Livingstone, but if, as I think possible, they represent the same species as the specimen from Moreton Bay, Queensland, discussed under *Pentagonaster dubeni* in this paper, then *queenslandensis* would have to be relegated to the genus *Pentagonaster* because of the shape of the pedicellariae. Moreton Bay is about 250 miles south of the Capricorn group, the type locality of *Tosia queenslandensis*.

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(Where not otherwise stated the reproductions are natural size.)

PLATE 39

FIG. 1. *Luidia columbia* (Gray), type, dorsal view.

FIG. 2. *Luidia hardwicki* (Gray), type, dorsal view.

FIG. 3. The same in ventral view.

PLATE 40

FIG. 1. *Luidia scotti* Bell, type, dorsal view.

FIG. 2. *Luidia savignyi* (Audouin), 1904.3.3.66, dorsal view.

PLATE 41

FIG. 1. *Luidia alternata numidica* Koehler, 1910.8.3.1, dorsal view.

FIG. 2. *Luidia maculata* forma *herdmani* forma n., type, dorsal view.

FIG. 3. The same in ventral view.

PLATE 42

Pentagonaster pulchellus Gray

FIGS. 1 and 2. Ventral and dorsal views of the smaller type of *P. abnormalis* Gray. The least extreme form of *P. pulchellus*.

FIGS. 3 and 4. Ventral and dorsal views of the larger type of *P. abnormalis* Gray.

FIG. 5. Specimen 1949.2.4.2, dorsal view showing the tubercular mid-radial plates. $\times \frac{1}{2}$.

PLATE 43

Pentagonaster dubeni Gray

FIG. 1. Specimen 52.12.9.20, from Queensland, dorsal view.

FIG. 2. The type of *P. gunni* Perrier, from Tasmania, dorsal view.

FIG. 3. The type of *P. dubeni* Gray, from Western Australia, dorsal view.

PLATE 44

Pentagonaster dubeni Gray

FIG. 1. Specimen 52.12.9.20, ventral view.

FIG. 2. The type of *P. gunni* Perrier, ventral view.

FIG. 3. The type of *P. dubeni* Gray, ventral view.

PLATE 45

FIG. 1. *Tosia australis* forma *astrologorum* (Müller and Troschel), extreme form, specimen 62.1.8.19, dorsal view.

FIG. 2. *Tosia australis* Gray, specimen figured by Gray in 1866 so presumably the type, dorsal view.

FIG. 3. *Tosia nobilis* (Müller and Troschel), specimen 72.6.22.21, dorsal view.

FIG. 4. *Tosia nobilis* (Müller and Troschel), the type of *T. tubercularis* Gray, dorsal view.

FIG. 5. *Tosia magnifica* (Müller and Troschel), the type of *T. aurata* Gray, dorsal view.

FIG. 6. *Tosia nobilis* (Müller and Troschel) ?, the type of *T. rubra* Gray, dorsal view.

FIG. 7. *Tosia nobilis* (Müller and Troschel), specimen 1949.2.3.6, dorsal view.

PLATE 46

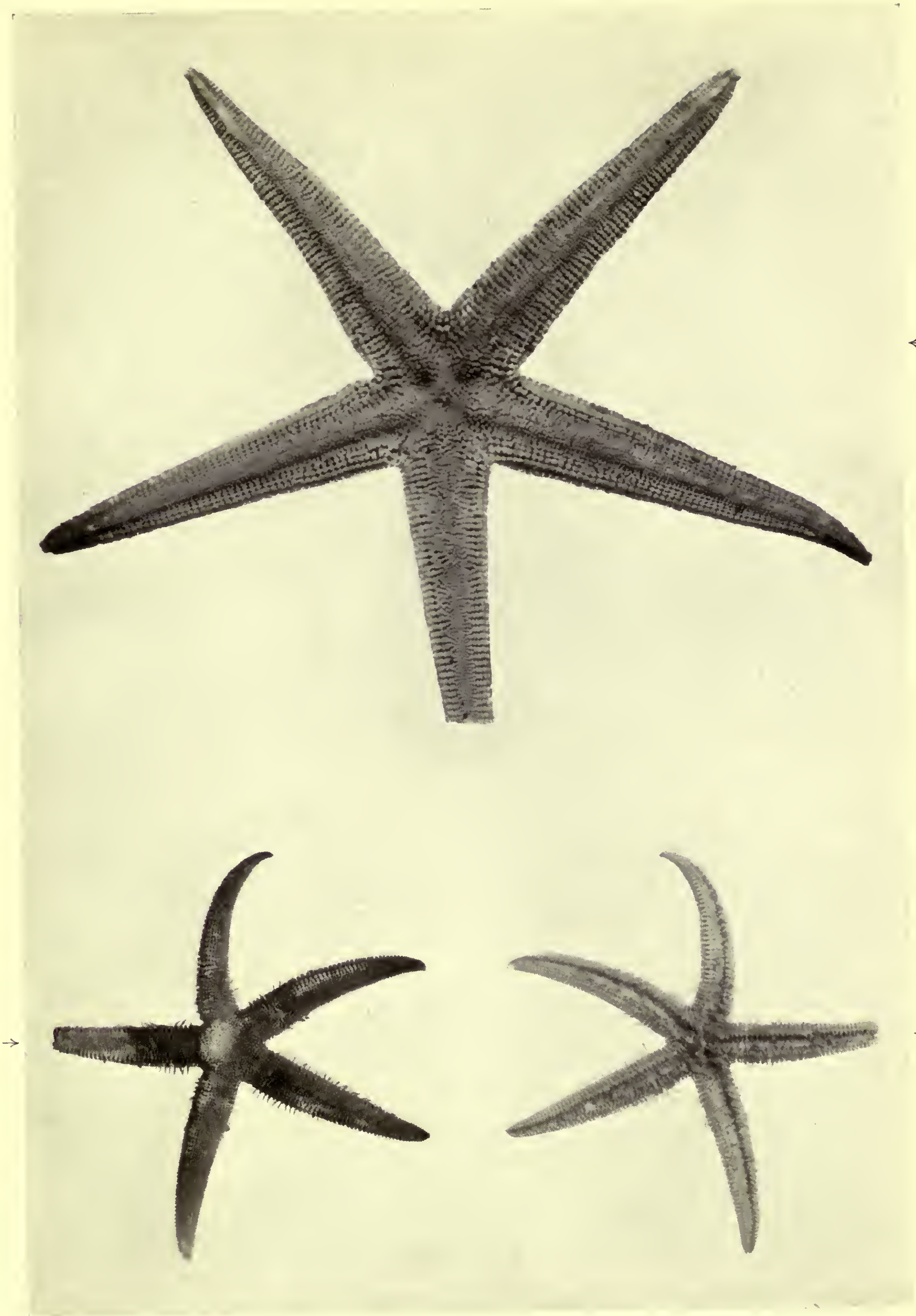
FIG. 1. *Tosia nobilis* (Müller and Troschel) ?, the type of *T. rubra* Gray, ventral view.

FIG. 2. *Tosia nobilis* (Müller and Troschel), the type of *T. tubercularis* Gray, ventral view.

FIG. 3. *Tosia australis* Gray, specimen figured in 1866, ventral view.

FIG. 4. *Tosia magnifica* (Müller and Troschel), the type of *T. aurata* Gray, ventral view.

FIG. 5. *Tosia magnifica* (Müller and Troschel), the type of *T. grandis* Gray, ventral view.



←1

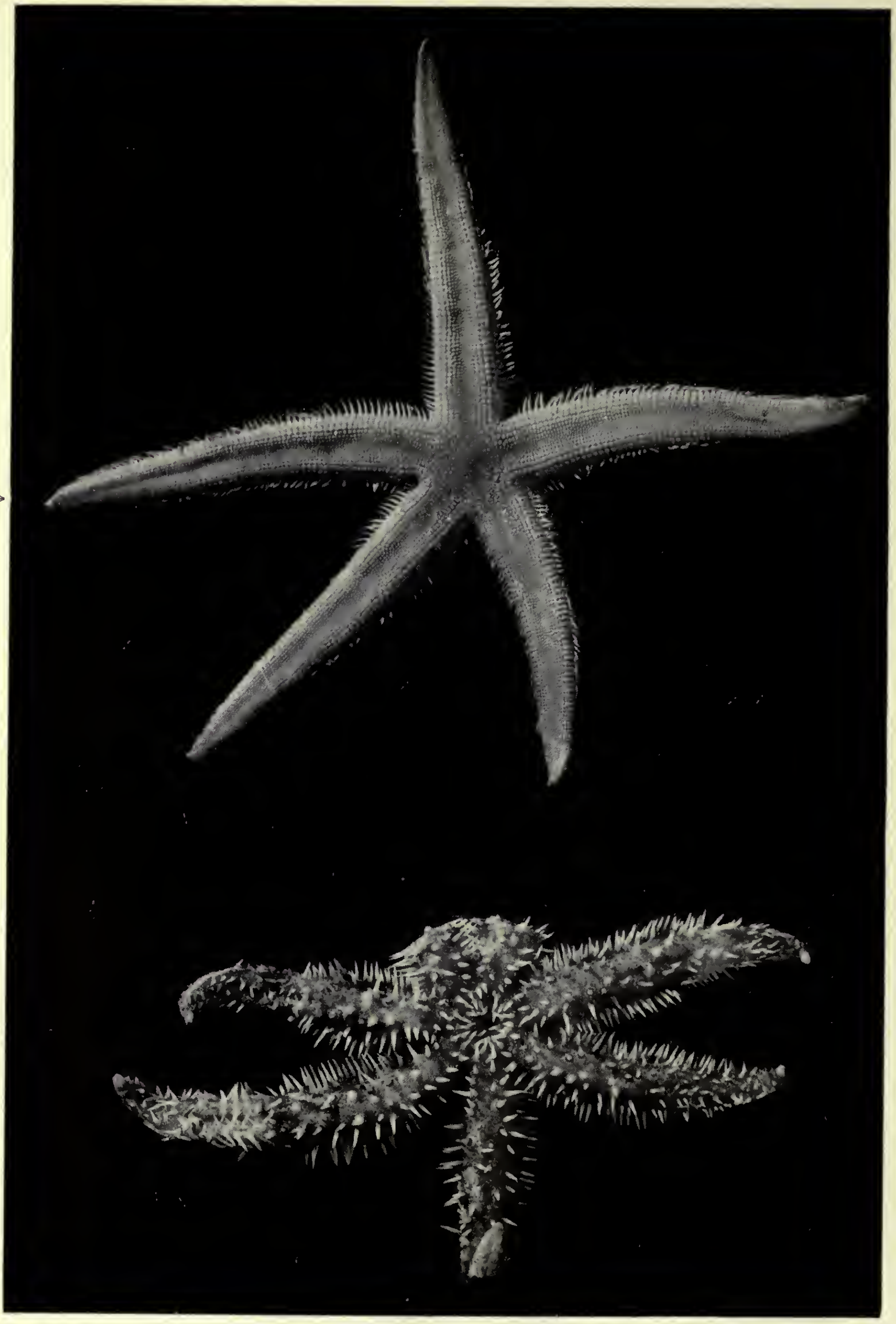
2→

←3

1. *LUIDIA COLUMBIA* (Gray)
2, 3. *LUIDIA HARDWICKI* (Gray)

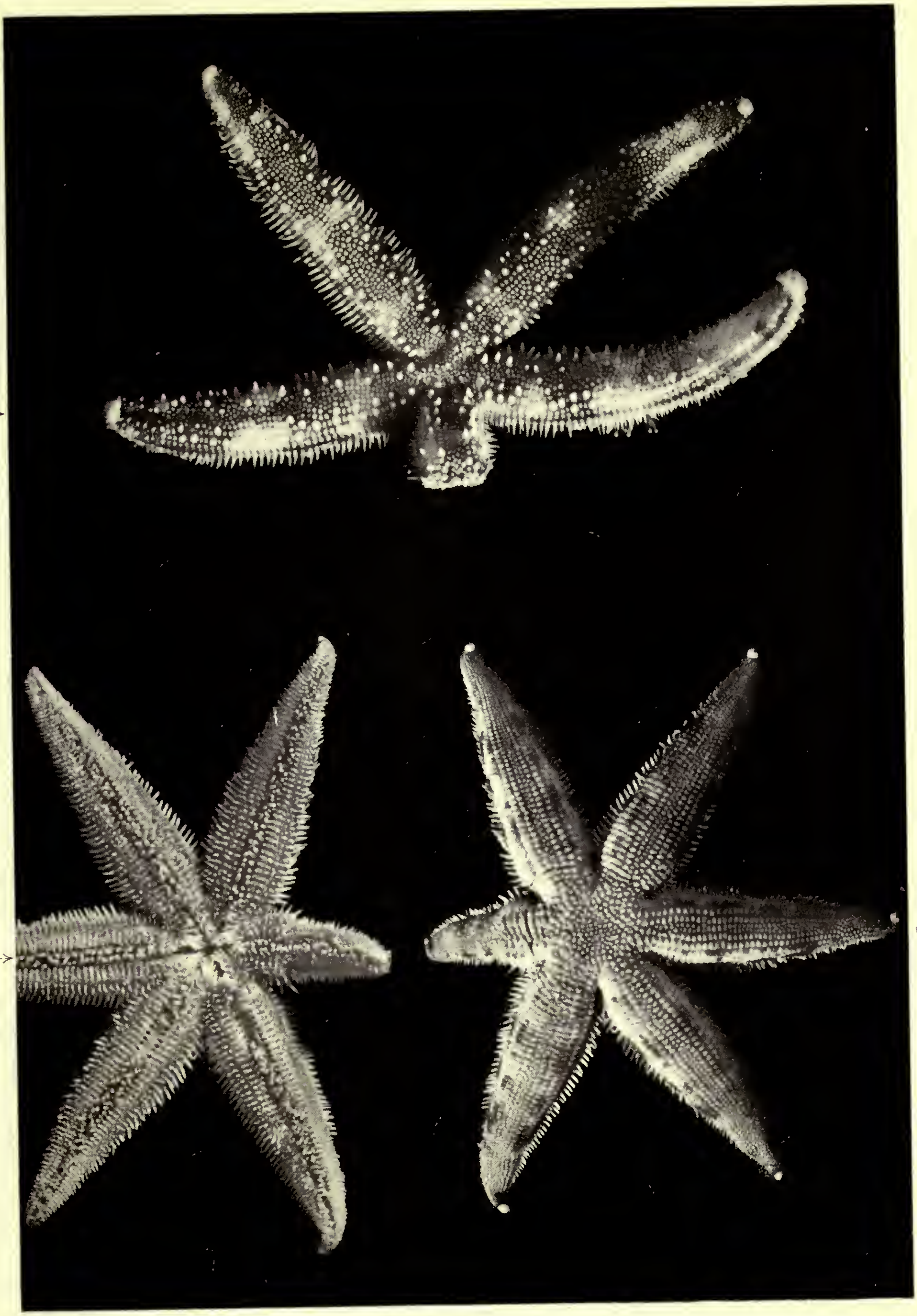
1→

2→

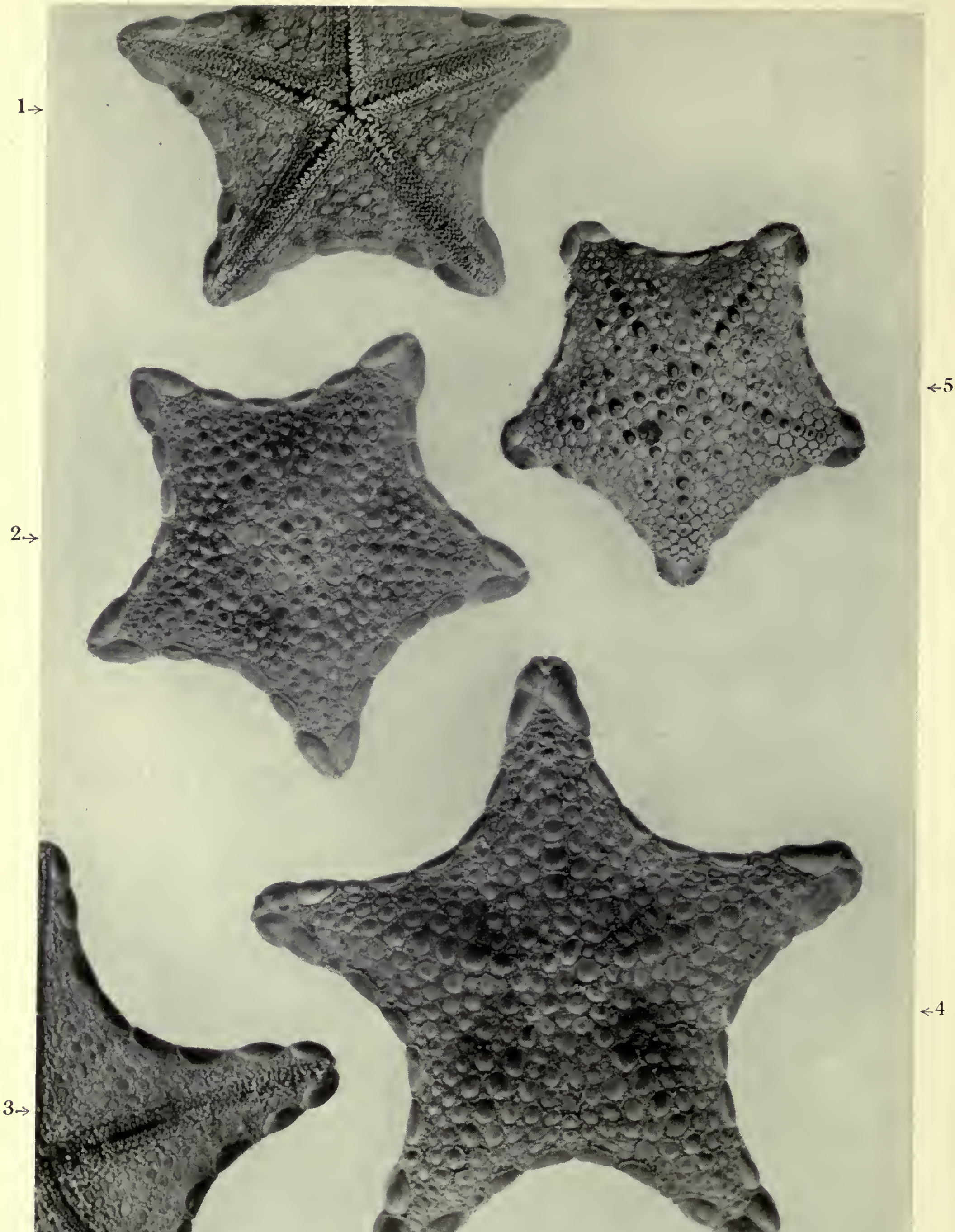


1. *LUIDIA SCOTTI* Bell
2. *LUIDIA SAVIGNYI* (Audouin)

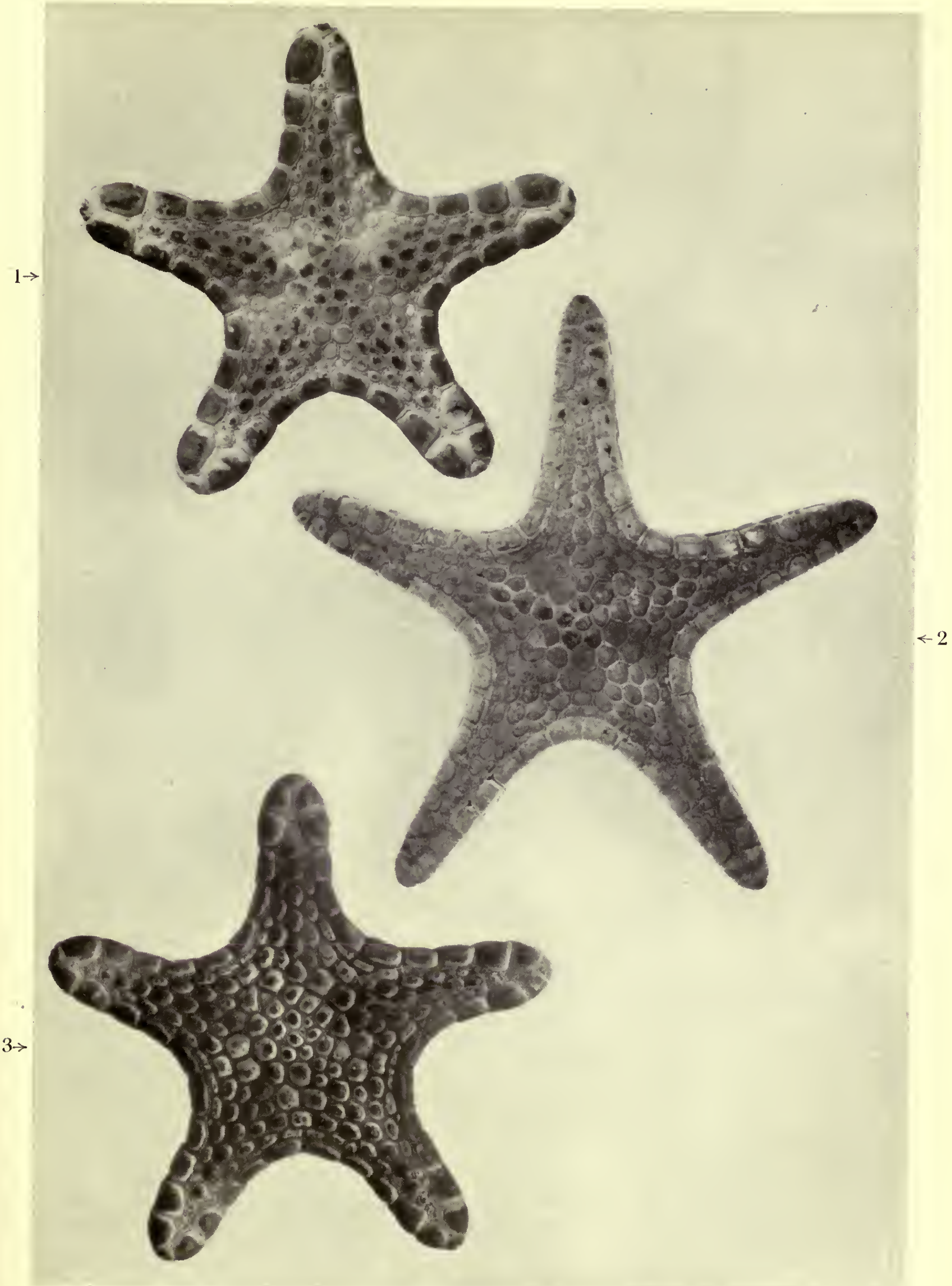
1→ 3→ ←2



1. *LUIDIA ALTERNATA NUMIDICA* Koehler
2, 3. *LUIDIA MACULATA* forma *HERDMANI* forma n.



PENTAGONASTER PULCHELLUS Gray



PENTAGONASTER DUBENI Gray

1→

←2

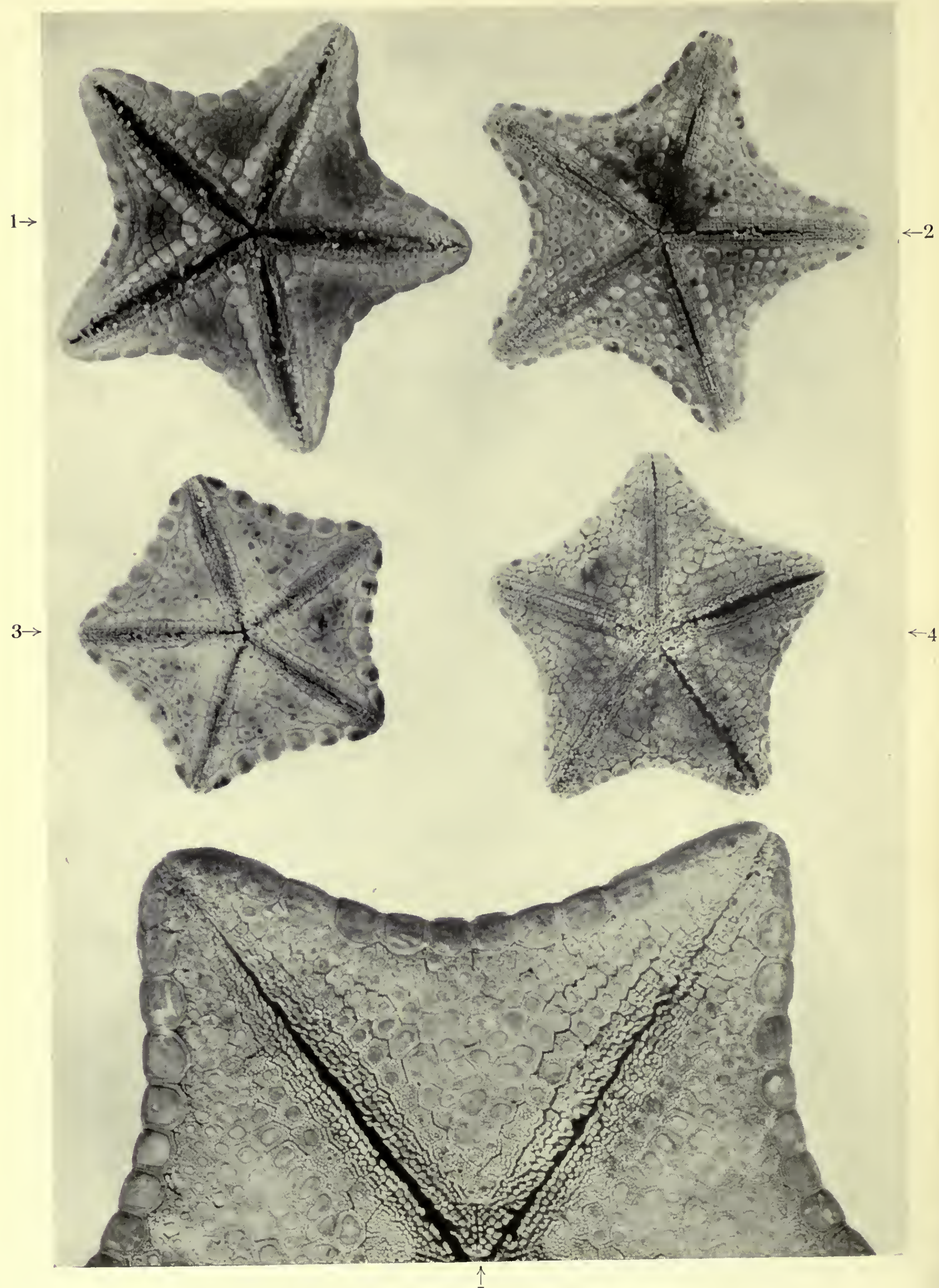
3→

PENTAGONASTER DUBENI Gray

1. *TOSIA AUSTRALIS* forma *ASTROLOGORUM* (Müller and Troschel)
2. *TOSIA AUSTRALIS* Gray

3, 4, 6, & 7. *TOSIA NOBILIS* (Müller and Troschel)

5. *TOSIA MAGNIFICA* (Müller and Troschel)



1, 2. *TOSIA NOBILIS* (Müller and Troschel)

3. *TOSIA AUSTRALIS* Gray

4, 5. *TOSIA MAGNIFICA* (Müller and Troschel)

SOME INTER-TIDAL MITES FROM SOUTH-WEST ENGLAND

By G. OWEN EVANS *and* E. BROWNING

SYNOPSIS

The distribution of ten species of inter-tidal Acari from south-west England is given, together with descriptions of *Lasioseius fucicola* Halbert (1920) and *Chaussieria maritima* sp. n.

THE Acari of the inter-tidal zone comprise two main groups: those which are typically terrestrial and those which are restricted to the inter-tidal zone. The latter exhibit structural modifications associated with mites living under semi-aquatic conditions. The chief modification affects the ambulacra of legs II, III, and IV which become long, hair-like lobes—a structure assisting the movement of the animal over a permanently moist substratum. Leg I, which is not usually used for locomotion, is normal.

The inter-tidal Acari do not show any modification in the organs associated with respiration. This suggests, as Halbert (1920) has pointed out, that these animals are not enveloped by the sea water but inhabit crevices, &c., where air is imprisoned during high tide. Many species of mites are found under deeply embedded stones together with springtails, beetles, and pseudoscorpions. Others (*Balaustium, Molgus*) run freely on rocks at low tide, especially in sunny weather, but are forced to seek the shelter of rock fissures, &c., by the incoming tide.

The major contribution to the study of sea-shore mites has been made by Halbert (1920). This investigator studied the distribution of Acari in relation to certain zones occupied by lichen and seaweeds. The richest population occurred in the zone lying between neap and high spring tide, a zone left dry for relatively long periods. There followed a marked decrease in the variety of forms towards low-tide marks. This was chiefly due to the absence of the terrestrial forms which formed the majority of the species around high-tide mark. Twelve species were recorded for the zones normally covered by the two daily tides.

The Acari described in this paper were collected by one of us (E. B.) during mid-summer in 1947 and 1949. The collecting was by no means exhaustive and was restricted to the area between low- and high-water marks in the following localities:

Devon

1. 'The Nest', Babbacombe, 11.7.1947, on rocks between tide marks.
2. Rock End, Torbay, 12.7.1947, on rocks between tide marks.
3. Carbons Head, Torbay, 13.7.1947, on rocks between tide marks.
4. Livermead, Torbay, 15.7.1947, on rocks between tide marks.
5. Oddicombe Beach, Babbacombe, 15.7.1947, on rocks between tide marks.
6. Carbons Head, Torbay, 17.7.1947, under stones below high-water marks.
7. Meadfoot Beach, Torbay, 18.7.1947, under stones below high-water marks.

Dorset

8. Peveril Point, Swanage, 14.7.1949, under stones below high-water marks.

MESOSTIGMATA

Gamasides

Parasitus kempersi (Oudemans 1902)

This is a species characteristic of the region between the high-water marks. Halbert (1920) records it as occurring abundantly under stones or seaweeds and also in moist shelly-sand and gravel where there are but few other species of mites. In the present investigation it was collected in relatively large numbers under stones below high-water mark at Meadfoot Beach, Torbay, and at Peveril Point, Swanage. In both cases the specimens were deutonymphs.

Eugamasus trouessarti (Berlese 1905)

According to Halbert (1920) this is an abundant species occurring in a variety of habitats in the intertidal zone. He records it from several localities in Ireland and Hull (1918) also records the species from Budle Bay, Northumberland. In the material from southern England it occurred only under stones below high-water mark at Carbons Head, Torbay.

Cyrthydrolaelaps hirtus Berlese 1905

A species occurring well below high-tide marks and showing the ambulacral modification associated with Acari inhabiting wet places. According to Halbert (1920) the nymphal stage occurs higher up the shore than the adult. One female and two protonymphs (♂) were collected at Rock End, Torbay, and one female at Carbons Head, Torbay. On both occasions the mites were collected on rocks between tide marks.

Halolaelaps marinus (Brady 1875)

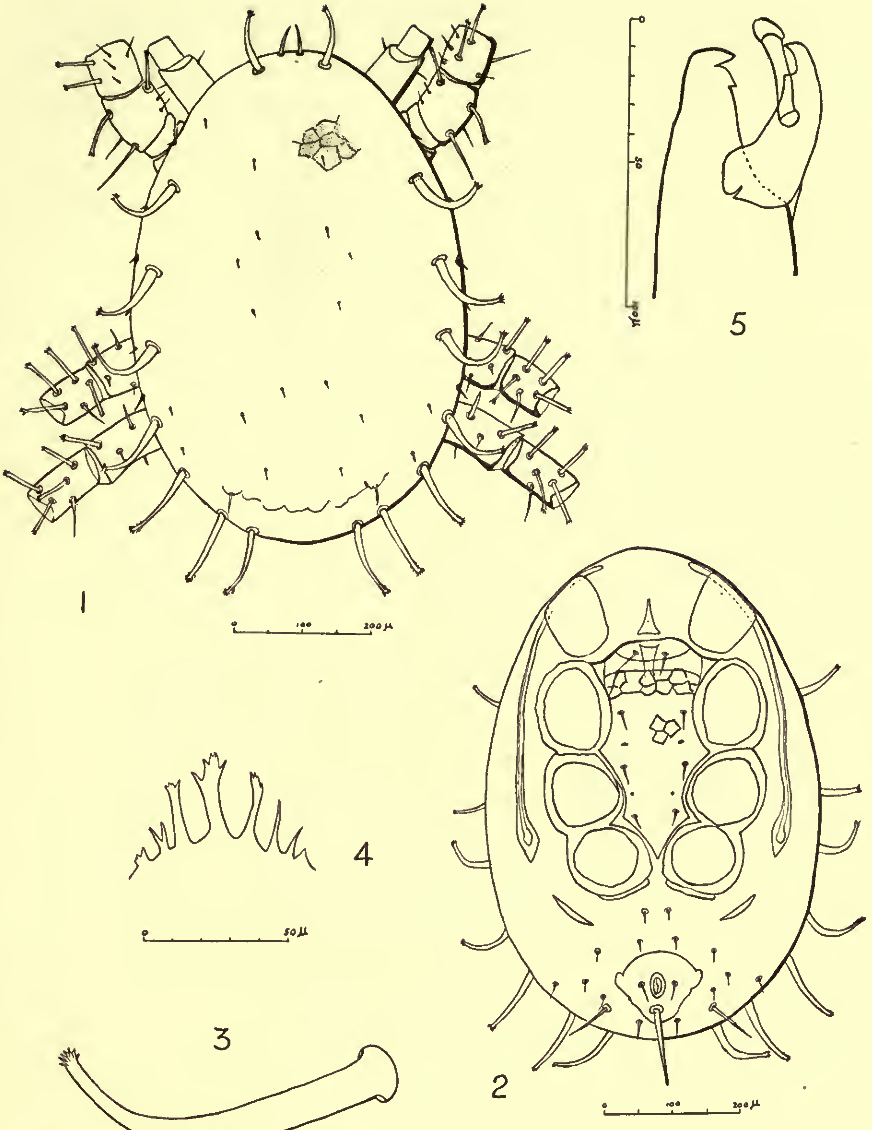
(= *Halolaelaps glabriusculus* Berlese and Trouessart, 1889)

As in the preceding species the ambulacra are modified and comprise a pair of flattened central lobes and a pair of long acute lateral lobes. It has been recorded by Halbert (1920) from Ireland and by Hull (1918) from a number of localities in northern England. One female occurred together with *Crythydrolaelaps hirtus* on rocks below high-tide marks at Carbons Head, Torbay.

Lasioseius fucicola Halbert 1920[1]

This interesting species was first described by Halbert (1920) from two males, one collected under seaweeds washed out of the Orange lichen zone at Malahide, Ireland, and the other from Swanage. The latter was included in a collection of littoral mites sent to Halbert by A. D. Michael. These appear to be the only published records of the species to date. During the present study a male and two deutonymphs of the

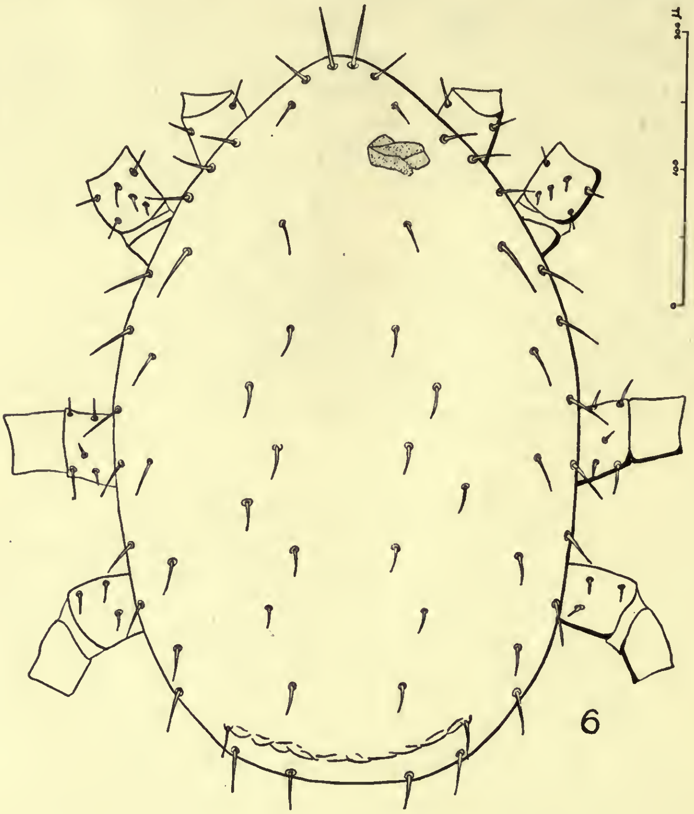
[1] Since going to press we have received a number of males and females of this species for identification. The females have proved to be identical with *Thinoseius berlesei* Halbert, 1920. Due to page priority the latter becomes a synonym of *L. fucicola*.



FIGS. 1–5. *Lasioseius fucicola* Halbert, male. 1. Dorsal view. 2. Ventral view. 3. Dorsal spine. 4. Epistome. 5. Mandible.

species were found under stones at Peveril Point, Swanage. A redescription of the male and a description of the hitherto unknown deutonymph is given below:

Male (Figs. 1–5). Body oval, slightly flattened posteriorly. Length 0·737 mm.,



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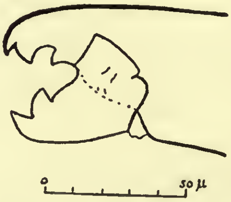

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FIGS. 6–7. *Lasioseius fucicola* Halbert, deutonymph.
6. Dorsal view. 7. Mandible.

breadth 0·495 mm. The dorsal surface strongly reticulated and covered with fine punctations. The reticulations become stronger posteriorly and assume a scale-like appearance. On each side of the dorsum a row of eight strong spines, smooth except for a clump of short spines distally (Fig. 3). The first pair situated postero-lateral to the pair of shorter vertical spines. The remainder of the chaetotaxy of the dorsum is

composed of short setae arranged as shown in Fig. 1. Sternal shield V-shaped terminating in a marked point between coxae IV and with sharp projections between coxae II–III and III–IV. It is strongly reticulated and bears the normal four pairs of hairs and three pairs of pores. Metapodalia elongate and situated postero-lateral to

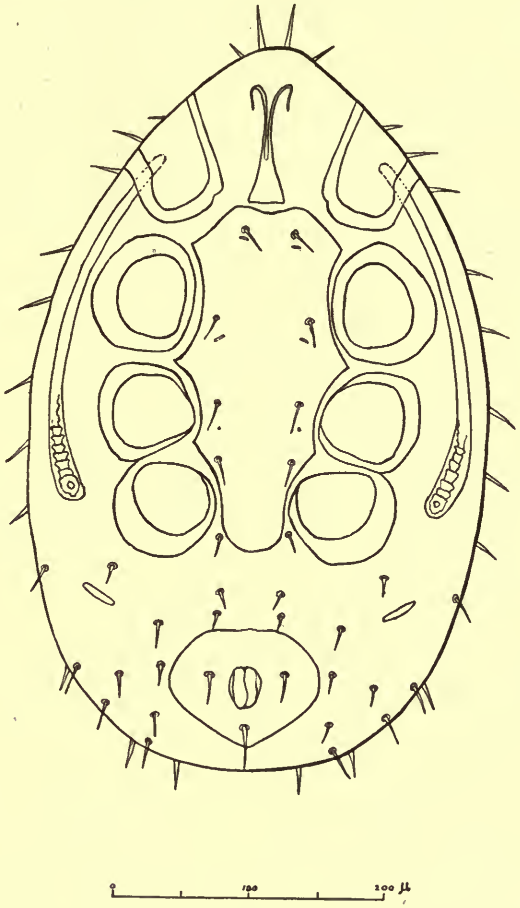


FIG. 8. *Lasioseius fucicola* Halbert, deutonymph.
Ventral view.

coxae IV. Stigma situated between coxae III and IV and peritremata extending beyond the level of coxa I. Anal shield small, semicircular anteriorly but tapering to an obtuse point posteriorly. One seta each side of anal opening and a large strong terminal spine projecting beyond posterior border of the body. Epistome multidentate, terminal portions branched (Fig. 4). Segment I of maxillary palps with two strong blunt spines ventrally, segment II with five shorter spines of which three are dorsal. Digitus fixus and digitus mobilis of mandible unidentate (Fig. 5). Digitus mobilis with a strong club-like process issuing from about the middle of the digit and a marked cleft posteriorly. Legs, excluding first pair, strongly formed and carrying

strong spines—the majority of these are of the same form as the eight pairs of large dorsal spines. Ambulacra with two terminal hairs.

Deutonymph (Figs. 6–8). Dorsal shield, length 0·55 mm., breadth 0·33 mm., more pointed than in the male, chaetotaxy composed of simple spines arranged as in figure. Ornamentation (reticulations and punctations) as in male. Sternal shield V-shaped with posterior end rounded and terminating almost in line with the posterior border of coxae IV (Fig. 8). Shield strongly projecting between coxae II–III, III–IV and with normal four pairs of setae and three pairs of pores. Metapodalia as in male. Stigmata situated between coxae III and IV, peritremata extending to the middle of coxa I. The three setae on the anal shield of approximately the same length, the terminal one not projecting beyond the posterior edge of the body. Epistome as in the male. Digitus fixus of mandible bidentate, digitus mobilis unidentate (Fig. 7). All spines on legs I–IV simple.

PROSTIGMATA

Trombidiformes

Molgus littoralis (Linné, 1758)

One of the largest and most conspicuous mites occurring in the inter-tidal zone. It is often observed running freely over the rocks during sunny weather, but retreats into rock fissures, &c., before the incoming tide. The species was found at Babbacombe, Carbons Head, and Livermead.

Bdella ?decipiens Thorell, 1872

A nymph probably referable to this species was found on one occasion with *Molgus littoralis* (Linné) on rocks between tide marks at Babbacombe.

Balaustium rubripes (Berlese and Trouessart, 1889)

(= *Ritteria hirsutus* George, 1910)

A brightly coloured mite occurring in large numbers below high-water mark on the coasts of France and the British Isles. Trouessart (1888) and Halbert (1915) observed it occurring abundantly on rocks covered with *Balanus balanoides*. We have found this species in quantity at Carbons Head, Livermead, and Oddicombe Beach. The majority of specimens appeared to have discarded their legs on being placed in Oudemans fluid.

Balaustium araneoides (Berlese, 1910)

This species was first described by Berlese from specimens collected at Palermo, Sicily. Halbert (1920) recorded it from Malahide, where it occurred abundantly on limestone rocks below high-water mark. Our specimens were collected with *B. rubripes* on stones between tide marks at Oddicombe Beach. The crista conforms with that figured by Halbert (1920).

Chaussieria maritima sp. n.

Oudemans (1936) in his revision of the family Anystidae erected the genus *Schellenbergia* with *Erythraeus domestica* C. Koch (1847) as the type of the genus. In 1937 the same author substituted the name *Chaussieria* for *Schellenbergia* which was preoccupied. The characters of the genus *Chaussieria* are as follows (Oudemans, 1936):

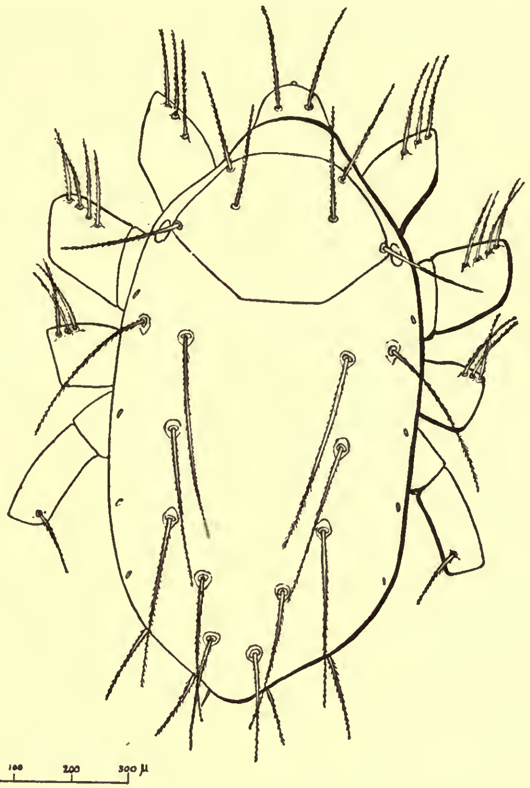
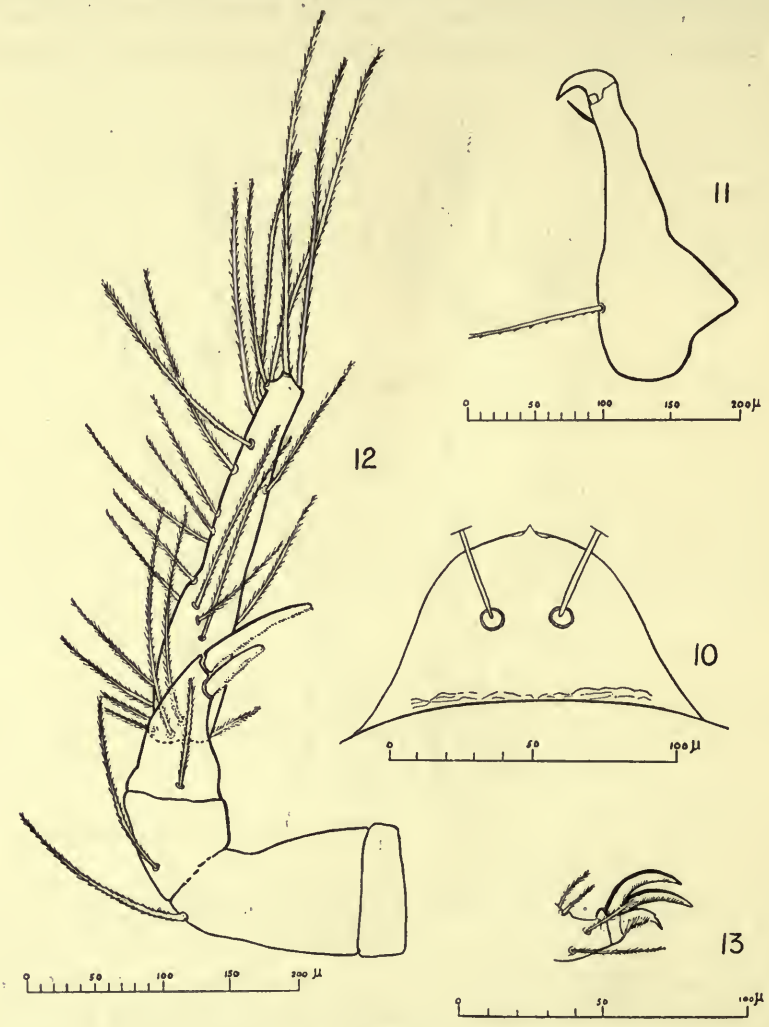


Fig. 9. *Chaussieria maritima* sp. n., female.
Dorsal view.

Two eyes. Dorsal shield broader than long. Dorsal setae arising from plate-like structures. Peritremata ∽ shaped, becoming broader distally with its ends projecting freely. Four pairs of lentiform organs ('linsenförmiger' organs). Mandibles with two setae. Epivertex ('Kissen') with a small terminal projection. Basi and telofemur of all legs fused, tarsus shorter than tibia and subdivided into a long basitarsus and a shorter telotarsus. Coxae almost touching along the median line. Male unknown?

Female (Figs. 9–14). Body almost elliptical (Fig. 9). Length 0·97 to 1·03 mm. Breadth 0·33 to 0·35 mm. Colour, in preserved specimens, reddish brown. Body extended anteriorly into a conspicuous epivertex ('Kissen') carrying a pair of pseudostigmatic organs midway along its length. Epivertex with small terminal projection

(Fig. 10). Peritremata normal for the genus. Dorsal shield broader than long and with three pairs of long finely feathered setae. External scapular setae 1·97 mm. long. Two eyes situated one on each side of the lateral corner of the shield. Remainder of



FIGS. 10–13. *Chaussieria maritima* sp. n., female. 10. Epivertex. 11. Mandible. 12. Maxillary palp. 13. Claws and empodium of tarsus.

dorsum with six pairs of finely feathered setae arising from plate-like structures. Setae becoming progressively shorter towards the posterior end of the body. Four pairs of lentiform organs. Coxae cylindrical and almost meet in the middle line. Genital plate long and narrow with two longitudinal rows of feathered setae (Fig. 14). External row reaching to less than half-way along the plate. Posteriorly on each side of the genital plate a row of approximately thirty feathered setae running parallel

with the hind margin of the body. A number of the setae project beyond the margin of the body. Anterior-laterally, on each side, a row of more widely separated feathered setae. Mandible (0·22 mm. long) with two setae, proximal one long and feathered, distal one short and smooth (Fig. 11). Palp strong, with a long tarsus (approximately equal in length to the remainder of the palp) (Fig. 12). Division between palp femur and palp genu incomplete. Femurogenu (0·17 mm.) with two setae and terminating

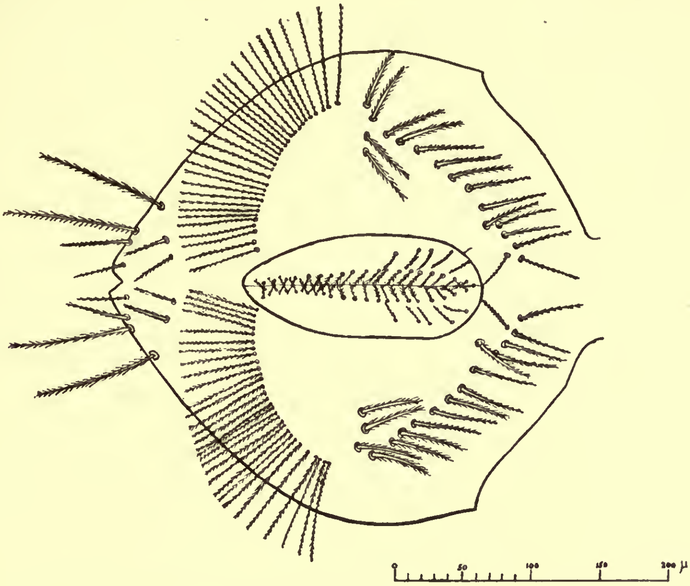


FIG. 14. *Chaussieria maritima* sp. n., female. Ventral view posterior to coxae IV.

in two strong claws; secondary claw being the shorter. The long palp tarsus (0·28 mm.) thickly covered with setae. The three longest terminal setae 0·22 mm. in length. All the setae on the palp are feathered. Legs long and thickly covered with strong feathered setae. Leg I 1·20 mm., leg II 1·45 mm., leg III 1·15 mm., leg IV 1·81 mm. The short telotarsus terminates in two claws and an empodium (Fig. 13).

Locality. Five females collected from stones between tide marks on Oddicombe Beach, Babbacombe, South Devon.

This species is closely related to *C. venustissimus* (Berlese, 1882), from which it may be separated by the following characters:

Genital plate narrower, not extending far between the posterior row of feathered setae. Setae of this row more numerous (30 either side of the middle line as opposed to about 12 figured for *C. venustissimus*), a number extending beyond the hind margin of the body, and all setae feathered along their entire length. In his description and figure of *C. venustissimus*, Berlese (1882) has shown these setae to be feathered distally only. Terminal setae of the maxillary palp longer.

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PRINTED IN
GREAT BRITAIN
AT THE
UNIVERSITY PRESS
OXFORD
BY
CHARLES BATEY
PRINTER
TO THE
UNIVERSITY

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